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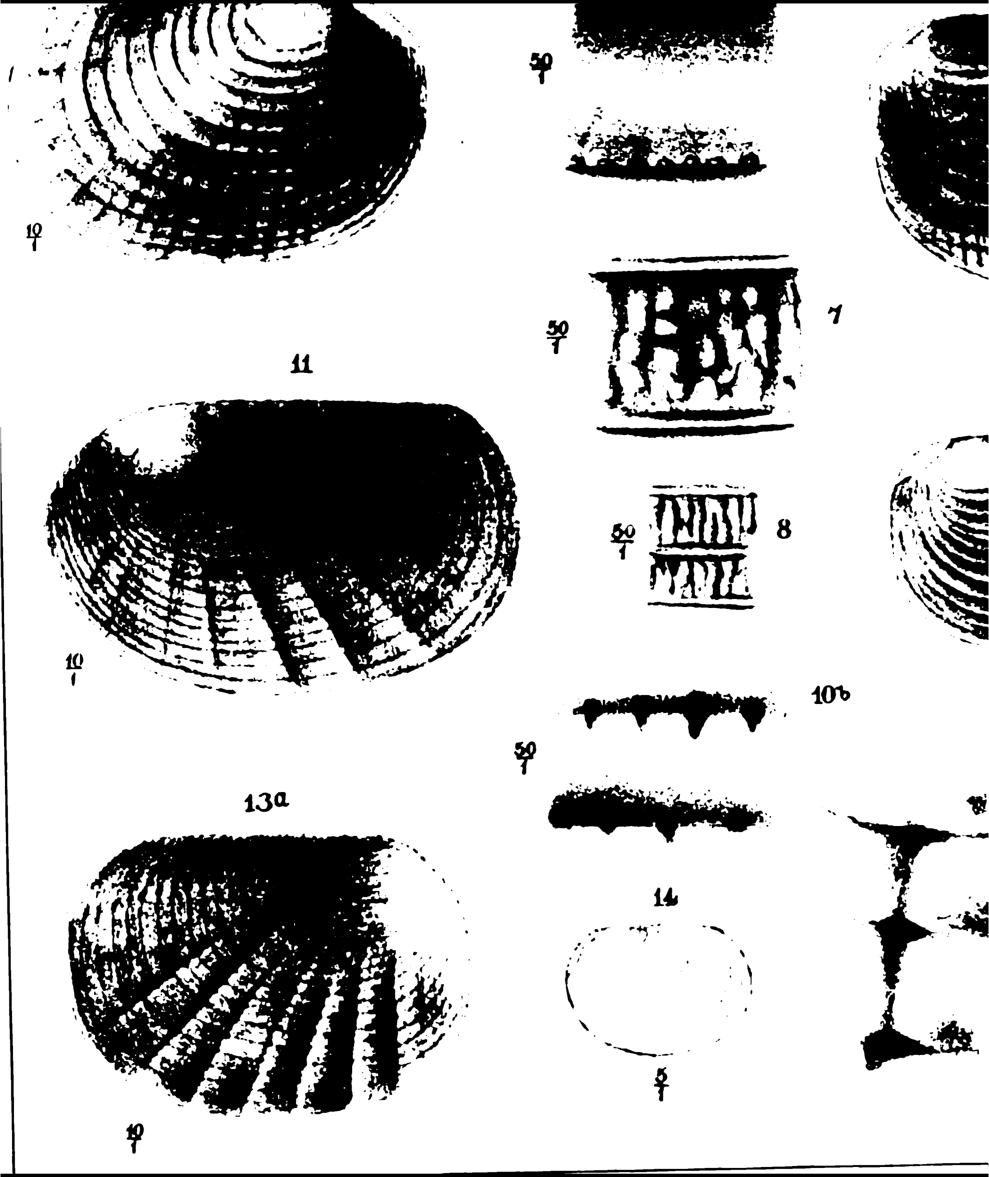

Geological magazine

Henry Woodward

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THE

GEOLOGICAL MAGAZINE:

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"THE GEOLOGIST."

NOS. CCCXIX. TO CCCXXX.

EDITED BY

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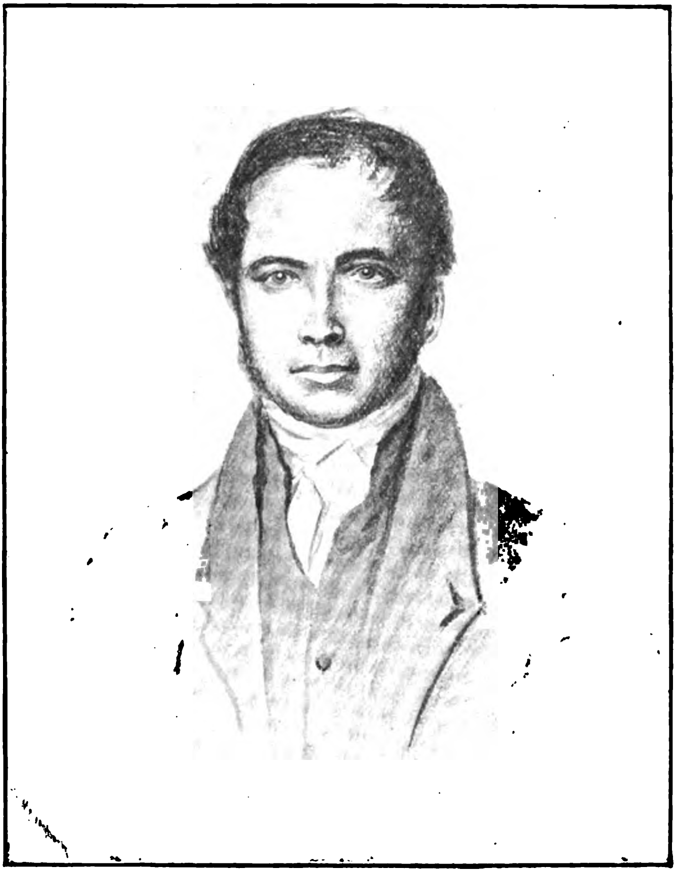

Sam Woodward

Frontispiece to the GEOLOGICAL MAGAZINE, DEC. III. VOL. VIII. No. 1, *for January*, 1891.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VIII.

No. I.—JANUARY, 1891.

ORIGINAL ARTICLES.

I.—A Geologist of a Century Ago:

Samuel Woodward of Norwich, Antiquary and Geologist.[1]

(With a Portrait.)

GEOLOGISTS are so accustomed to deal with vast periods of time, that a century may be deemed by them as equivalent to the moment-measure of the dial, or the sand-grains of the hour-glass.

Nevertheless a century, in human affairs, especially that just expiring, has for us a vastly wider significance, and although its passage may not have seen the birth, it has witnessed all the growth and development of Geological science, and a large proportion of that of her sisters also. It cannot be without interest, therefore, briefly to record in these pages the name of one who, although born a hundred years ago, with but scanty opportunities either of position or education to assist him, yet by sheer force of energy and perseverance, and attracted by a strong love of Nature, became a geologist of no mean merit, and left behind him a name honoured by those who knew him, and a record of work accomplished, worthy to fill a much longer life.

Samuel Woodward was born at Norwich, on the 3rd October, 1790. His grandfather, Simon Woodward, came from London to settle in Norwich, where he married and left two children, the younger of whom, William, born in 1762, married, in 1789, to Elizabeth Springall, and died in 1795, at the early age of 33 years. He left a widow and two children, the elder of whom was Samuel Woodward, the subject of the present Memoir. His father died before he was five years old, and after attending a day-school for a short time, he was placed under the care of a relative who was a shawl-weaver, then one of the staple manufactures of Norwich. So desirous was the boy to learn that he devoted every spare moment to study, and read with eagerness every book which came within his reach. At ten years of age we find him singing, as a chorister, on Sundays, in St. George's Colegate, the church of the parish in which he lived with his mother. Here he was introduced to Mr. Alderman Herring, a wealthy manufacturer, and at one time Mayor of Norwich, who kindly took the lad into his warehouse, and having first placed him in a school for a short time, he afterwards bound him apprentice to his own business, that of weaving Camlets and Bombazines. Here he gradually rose to a position of trust and responsibility; nor did he, during this period of twelve years, neglect any opportunity of improving his mind, eagerly availing himself of the kind permission given him by Mr. Herring to use his library for study whenever he had leisure to do so. His pursuits had already assumed the form they retained in later life. He collected and cultivated flowers, and his room was adorned with curios and shells which he bought at the old-curiosity shops in the city.

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[1] Those who are interested in the story of a Norwich boy who became a geologist may read the fuller account, of which this is but an abstract, in the Transactions of the Norfolk and Norwich Naturalists' Society, vol. ii. pp. 563–593, 1879, by Horace B. Woodward, F.G.S. (grandson of Samuel Woodward), and author of the "Geology of England and Wales," one of the best text-books ever written. The portrait is reproduced by permission from an original sketch, in Indian ink, in the possession of his daughter, Mrs. T. G. Bayfield of Norwich, drawn from life by his eldest son, B. B. Woodward.—Edit. Geol. Mag.

One of the first geological puzzles he endeavoured to solve was a mass of flint containing *Ananchytes*, which he had noticed on a cottage mantel-piece, where it was kept, well black-leaded, as an ornament. And one of the books which first excited his attention, and perhaps directed it to antiquarian and geological studies, was Verstegan's "Restitution of Decayed Intelligence, in Antiquities concerning the most noble and renowed English Nation," a curious work, of which the first edition was published in 1605, and in which the former connection between England and France was then advocated.

He not only used every opportunity of adding to his own store of knowledge, but was ready to help others, for he himself taught in both an evening and a Sunday school. It was whilst thus engaged that he became acquainted with Joseph John Gurney, who, throughout his life, proved a true friend to him.

In 1812 Mr. Herring gave up his manufactory owing to the general depression of business, but in 1814 Samuel Woodward obtained a clerkship in the Norwich Union Fire Office, which he held for six years, when he entered the Banking-house of Messrs. Gurneys' & Co., where he remained until his death.

In 1815 Samuel Woodward married Elizabeth, daughter of Bernard Bolingbroke, Esq., of East Dereham, Norfolk, and niece of Nathaniel Bolingbroke, Esq., formerly Mayor of Norwich, and of Sir John Yallop, Sheriff of that city. This union resulted in a family of six sons and three daughters; but one son and one daughter died in their infancy.

After 1820, he was brought prominently under the notice of Hudson Gurney, Esq., M.P., of Keswick, and Dawson Turner, Esq., of Yarmouth, both Fellows of the Royal Society, and partners in Gurney's Bank. It was to their friendly aid and encouragement that he largely owed the opportunities he enjoyed for the prosecution of his favourite studies, and also the success which attended his labours. To them he was particularly indebted for the loan of books, and for aid in his publications.

The works of Parkinson, William Smith, and, later on, those of

Conybeare and Phillips, became his text-books; while the writings of Richard Taylor gave an impetus to his local researches. Taylor's earliest paper was published in 1822,[1] and in the following year Samuel Woodward made his first geological tour of the coast, but without obtaining any specimens of fossil bones. In 1824 Mr. Robert Lacy sent him two molars of Elephant from Mundesley, and soon after he made another excursion from Yarmouth to Cromer along the beach, and obtained some good specimens; and might, he says, have obtained some very large and fine bones, but for the difficulty of conveyance.

From this year and up to the time of his death he maintained a considerable correspondence with many of the leading naturalists and geologists of the day. The letters he received, together with many miscellaneous notes and memoranda, are preserved in eleven quarto volumes, now in the possession of his youngest son, Dr. Henry Woodward, F.R.S. During this period of fourteen years he seems to have kept every scientific letter he received, and it must be remembered that in those days letter-writing was, as a rule, far more elaborate and careful than it is now. Many of these letters are only of value as autographs, and merely relate to inquiries as to coins, rings, seals, merchants-marks, ancient buildings, and other antiquarian matters mostly of local interest. Others bear upon geological topics: amongst them we find letters from William Bean (of Scarboro'), C. W. Peach, R. C. Taylor, Hudson Gurney, Dawson Turner, the Rev. James Layton (of Catfield); Thomas Amyot (Treasurer of the Society of Antiquaries), J. W. Robberds, Miss Etheldred Benett,[2] Goddard Johnson, H. Denny (of Leeds), Daniel Stock (of Bungay), Dr. Buckland, Prof. Sedgwick, Dr. Mantell, G. B. Baker (of Bungay), Dr. Charles König (British Museum), Sir R. I. Murchison, Prof. John Phillips, Dr. James Mitchell, Wm. Gilbertson (of Preston), the Rev. Thomas Image (of Whepstead), the Rev. George Munford, the Rev. W. Foulger. There are also short notes from Fitton, De la Beche, Lyell, Agassiz, Sir Philip Egerton, Elizabeth Fry, Harriet Martineau, and Charles Waterton.

Samuel Woodward's first letter to Mr. Caleb Rose, F.G.S., of Swaffham, was written in May, 1826, and from that date there was an uninterrupted correspondence, mostly on geological topics, until the death of the former in 1838. The enthusiasm of the two friends seems to have been very great; every discovery of a new fossil was at once communicated, while books and specimens were borrowed and exchanged, in a way that speaks well for the prosecution of science in those days.

In 1824 he made his first communication to one of the learned Societies of London. It consisted of a series of maps and plans of Ancient Norfolk, which he submitted to the Society of Antiquaries through Mr. Hudson Gurney. One of these maps illustrated the Roman period, showing the several stations and roads constructed by the Romans; another pictured the great estuary which it was considered had spread itself as far as *Venta Icenorum* (Norwich) before the sands on which Yarmouth was built were left uncovered by the sea. This latter map was based upon the ancient 'Hutch Map,' belonging to the Corporation of Yarmouth, with, however, many inaccuracies as to places and distances corrected.

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[1] "Fossil Bones on the Coast of East Norfolk," Phil. Mag. vol. lx. p. 132, 1822.

[2] Well known to geologists as authoress of "A Catalogue of the Organic Remains of the County of Wilts," 1831; (of Norton House Warminster, Wilts).

In 1825 he had already nearly completed two works in MS., one entitled "Sketch of the Norwich Crag Deposit, with a Descriptive Catalogue of its Fossils," a quarto volume containing twenty plates with outline figures of the species; the other, entitled, "Remarks on the Geology of the County of Norfolk," 4to. illustrated with coloured figures of the fossils and coloured sections of the strata. Both works, however, were commenced and carried out on a plan far too ambitious and expensive for publication. The projected "Geology of Norfolk" was to comprise 24 plates, and nearly 1000 figures; he had already drawn about 300, and others were subsequently added; these remain as he left them. The substance of his observations, and figures of many of the species were, however, published in his "Geology of Norfolk," in 1833. The original drawings of fossils are extremely accurate and very carefully executed and bespeak considerable native talent. In 1826 he was elected a member of the Committee of the Norfolk and Norwich Museum (established in 1824), an office which he held at intervals during the subsequent years of his life. In 1827 he exhibited before the Society of Antiquaries, in London, some antiquities found at Coltishall, which he conjectured to have been a landing-place to the Romans when navigating the River Bure on their way to Bampton or Burgh-by-Aylsham. Later in the year he was engaged with Mr. W. C. Ewing, in exploring the Barrows at Eaton Heath. The Bronze Celts and a perfect metal mould obtained there, were exhibited at the Society of Antiquaries, Dec. 6, 1827 (see Archæologia, vol. xxii. p. 424, 1829). On the 5th Feb. 1828, he was elected an Honorary Member of the Yorkshire Philosophical Society, at the suggestion of John Phillips, then Curator of the York Museum, with whom he frequently corresponded.

In 1828, in a letter to Dr. Fitton, F.R.S., President of the Geological Society of London (read 2nd January, 1829), he records the occurrence of Crag at Cromer, and westward at Coltishall, and around Norwich. To the eastward, instead of marine shells, he noticed that there occurred a layer of ligneous and mammalian remains reposing on the Chalk. In this, immense numbers of bones and teeth of the Elephant, Horse, Deer, etc., mingled with trunks, branches, and leaves of trees, had been found, extending even to the distance of twenty miles out to sea, and on the Knoll sands, etc. (Proc. Geol. Soc. 1829, vol. i. p. 93). In 1829, he communicated a short sketch of the geology of the county to the "Norfolk Tour," in which he states that in what was subsequently termed the "Forest Bed" there are found a surprising number of vegetable and animal remains, as trunks, branches, leaves, and stumps of trees (*in situ*), etc. He had two years previously (1827) recorded that in his own collection from the coast were remains of Elephant, Rhinoceros, Hippopotamus, Horse, Bos, Irish Deer, and three other species of Deer.[1] Many of these were obtained from the oyster-bank off Hasboro', which he regarded as an extension of the blue clay of the cliff. He also observed that "the antlers of the deer are broken into fragments of from six to eight inches in length, and three-fourths of them had been shed, indicating that they were at present not far removed from their original locality, and appeared to confirm the tradition that this part of the sea, called 'the Holmes,' was originally a forest."

In a second communication to Dr. Fitton (23rd March, 1829), he pointed out that "Wherever a section has been made of the Crag of Norwich, with one exception, there has been found a layer of nodular flints from twelve to eighteen inches in thickness reposing on the Chalk. Reasoning from analogy he concluded that the Chalk in these instances had been subject to the action of currents of water previous to the deposition of the (Crag) shells; as the appearance of the flints perfectly agrees with the like phenomena going on at Foulness Point, Cromer, and at Trimmingham Beach, on our coast; . . . . The Chalk under these flints is perforated as if by *Pholades*." These notes, although not published at the time, appeared later on in the "Geology of Norfolk."

In April, 1829, he sent to Mr. Amyot some "Fragments illustrating the History of Norwich Castle;" and in May, some "Observations on the Round Towers of Norfolk," for the Society of Antiquaries. At the request of Mr. Daniel Gurney, he directed his attention, in 1825, to the collecting and publishing of Merchants' Marks, and later on he exhibited six examples referred to dates between 1409 and 1608, which he had drawn on stone ready for publication.

For some time past his "Synoptical Table of British Organic Remains" had been in preparation, entailing much research and correspondence; it appeared on 1st July, 1830, the list of subscribers numbering 155. This work, naturally, has now been out of date long ago, having been superseded in 1843 by the "Catalogue of British Fossils," by Professor Morris, the second edition of which appeared in 1854, now 36 years since. Happily the Vertebrata have been brought up to date by Messrs. Arthur Smith Woodward and C. Davies Sherborn, but the Invertebrata have only been partially listed in separate works, so that much remains to be done in order to complete our Catalogue of British Fossils.

In 1832, Samuel Woodward visited Mr. Hudson Gurney in London, and went the round of the principal learned Societies with him; making the personal acquaintance of a number of eminent geologists and antiquaries whom he had previously known by correspondence. He also attended a conversazione at Mr. (afterwards Sir Roderick) Murchison's house, where he met Dr. Buckland and Mr. (afterwards Sir Charles) Lyell, and others.

The year 1833 saw the publication, on the 1st of May, of his "Outlines of the Geology of Norfolk," one of the first works describing the geology of any English county, and one which in its plan and scope has not at present been superseded. Much necessarily requires revision in the classification of both the strata and their included fossils; but the work has retained its place as a standard book of reference for Norfolk. He attended the meeting of the British Association at Cambridge in 1833, in company with his friend Mr. Caleb Rose, of Swaffham, but they do not appear to have been much gratified with their visit; for, as his friend afterwards remarked in a letter, "authorities were ponderous," and we were only "insignificant labourers."

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[1] See Rev. J. Layton, Edinb. Journ. of Science, vol. vi. p. 199.

In this year Professor Sedgwick was appointed a Canon of Norwich Cathedral, and his advent was indeed a happiness to the Norfolk geologist. Dr. Mantell, writing from Brighton (December 14th, 1834), says: "Believe me you are most fortunate to have such a man near you; it will more than compensate for your distance from all the other savants in England. I think Mr. Sedgwick by far the most talented and splendid man we can boast of. I only wish we had a Cathedral here, and he had a stall in it."

During the Professor's residence in Norwich, they not unfrequently met, Sedgwick often inviting Woodward to the Close, and coming occasionally to spend an evening at Grove Cottage, to look over the treasures in his geological collection.

In February, 1835, he delivered a lecture on "The Antediluvian Topography of Norfolk" at an evening conversazione of the Norfolk and Norwich Museum.

About this period his health seems to have been very feeble; he was suffering from a most trying complaint, diabetes. At times he had to relinquish his duties at the Bank, and seek in travel and change of scene, a temporary alleviation from his indisposition. Thus, on the 13th July, 1835, he went by packet to Yarmouth, and thence to Hull, where he inspected the Hull Natural History Museum with Mr. W. H. Dykes, and Mr. John Edward Lee, the Curator of the Museum. He next proceeded to Beverley, and afterwards to Scarborough, where he met Mr. W. Bean, Dr. William Smith, and Mr. Williamson, and was shown the geology of the coast by William Smith. Thence to York to visit John Phillips and the York Museum; afterwards to Leeds, to the Museum and to visit Mr. H. Denny. Then on to Preston to stay with Mr. Gilbertson, the well-known collector of Mountain Limestone fossils.[1] Later on he returned viâ Liverpool, and made his first railway journey from that city to Manchester, thence to Nottingham and so through Derbyshire by Buxton and Matlock to Derby and back to Nottingham, then on to Newark and so home viâ Sleaford, Lynn, and Dereham to Norwich, a truly formidable journey in those days.

In 1836 we find him again in London, seeking health, though mostly visiting amongst friends and attending the meetings of scientific societies.

In September, the Marquis of Northampton, who was much interested in geology, visited him at Grove Cottage, Lakenham, in order to see his collections; also Mr. Joseph Prestwich, jun. (afterwards Professor Prestwich, F.R.S.) who, paid his first visit to the Thorpe Crag-pits under Mr. Woodward's guidance, and there obtained a fine molar of *Elephas meridionalis*, now in the Norwich Museum.

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[1] Whose collection, like William Smith's, is now preserved in the British Museum (Natural History).

Although his bodily powers failed him, his mental energies never ceased to display their activity, and even at the last he occupied himself with numerous archæological subjects, and with the preparation of a new work, "Theoretical View of the Geology of the Norfolk Coast," a MS. which was never published.

He was also engaged in the preparation of his "History and Antiquities of Norwich Castle," edited, after his death by his eldest son, B. B. Woodward, F.S.A., in 1847; and in gathering materials for the "Norfolk Topographer's Manual," revised, augmented, and edited by W. C. Ewing, and published in 1842. Nothing could exceed the sympathy and kindness shown to Mr. Woodward during his last illness by all his friends, but his malady baffled medical skill, and he died on the 14th January, 1838, in his 48th year.

Thus ended a life of devotion to science, a life whose published works form but a partial memorial of the indefatigable industry of their author. "I believe," writes Prof. Sedgwick, "it is not too much to say that his life has been cut short by his devotion to science, and by his continuing (after the laborious duties of the day) to spend hours in study, which ought to have been given to rest." "His memory," writes his eldest son, "remains an object of reverence to his children, whose paths, by his patience and toil, have been made so easy and pleasant compared with his own, and of unfeigned respect to all who were acquainted with his character and his acquirements."

LIST OF WORKS BY SAMUEL WOODWARD OF NORWICH.

1829.—1. Geology of Norfolk. In "A General History of the County of Norfolk intended to convey all the Information of a Norfolk Tour." [By J. Chambers.] 2 vols. 8vo. 1829.

2. A Letter [to Dr. Fitton] respecting some remarkable fossil remains found near Cromer, in Norfolk. [Read Jan. 2nd.] Proc. Geol. Soc. vol. i. pp. 93, 94.

3. Musical Snails. Mag. Nat. Hist. vol. ii. p. 244.

4. [Notes on some Antiquities found in Norfolk.] Archæologia, vol. xxii. pp. 422–424.

1830.—5. On the Hydra, or Freshwater Polypus. Mag. Nat. Hist. vol. iii. p. 348.

6. A Synoptical Table of British Organic Remains: in which all the edited British Fossils are systematically and stratigraphically arranged in accordance with the views of the Geologists of the present day; and a reference given to their localities, strata, and engraved figures. 8vo. and 4to. London and Norwich.

1831.—7. Observations on the Round Church Towers of Norfolk; and on the materials employed in constructing the early religious buildings in that County. [Read May, 1829.] Archæologia, vol. xxiii. pp. 7–9.

8. A Descriptive Outline of the Roman Remains in Norfolk, accompanied by a Map of the County. [Read Dec. 1830.] *Ibid.* pp. 358–373.

9. A Copy of an Ancient Plan of the Chalk Vaults near St. Giles' Gates, Norwich: made by John Bond, 1571; exhibited, with notes, by Mr. Samuel Woodward. *Ibid.* pp. 411–412.

10. Natural History Collection. Mag. Nat. Hist. vol. iv. p. 177.

11. Luminosity of the Sea. *Ibid.* p. 284.

12. Ætites or Eagle Stones. *Ibid.* p. 468.

1832.—13. *Trichiosoma lucorum*, the Pupa and Imago of, a Habitat of, and the destruction of by one of the Ichneumonidæ. Mag. Nat. Hist. vol. v. pp. 85, 86.
14. Luminousness of the Sea. *Ibid.* vol. v. pp. 302, 303.
15. Origin of the Crag Stratum of Norfolk. *Ibid.* vol. v. pp. 544, 545.
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II.—ESSAYS IN THEORETICAL GEOLOGY.

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3. THE AGE AND ORIGIN OF THE HIMALAYAS, WITH ESPECIAL REFERENCE TO THE REV. O. FISHER'S THEORY OF MOUNTAIN FORMATION.

Introductory.

IT has become one of the truisms of geology that India, like Gaul, is divided into three parts, the Peninsular, the Extra-peninsular, and the Indo-gangetic alluvium.

Of these the first, the Peninsular, has been dry land since the Palæozoic period at least. It consists of a core of highly metamorphosed and contorted gneiss, on which are the remains of a skin of sedimentary rocks of various ages, and a vast expanse of trappean outbursts. Except in the Aravallis, the beds are but slightly disturbed, and the whole area has evidently been in a state of quiescence throughout the greater part of the period which has elapsed since the commencement of the sedimentary period. The region seems to have undergone but little oscillation of level, and such oscillations as have taken place never brought more than the margins of the area beneath the level of the sea. With the exception of the Aravallis before mentioned, there is no structural mountain-range in the Peninsular area, and such tracts as, from their elevation, deserve the name of mountains, owe their limitations to the action of subaerial denudation.

In contrast with this the Extra-peninsular area, if we except the Upper Tertiary beds at the top of the sequence and the Archæan gneisses at the base, contains few sedimentary rocks which are not of marine origin. Almost everywhere they are intensely disturbed, and the area is essentially one of structural mountain ranges, that is, of ranges whose general direction is closely connected with, and caused by, the disturbance the beds have undergone. Of this area we are at present concerned with the Himalayas, that system of mountains which rises abruptly from the plains of Upper India, range beyond range, to the snow-clad summits forming the highest spots on the surface of the Earth.

In the contour of the two areas there is a vast difference. The surface of the Peninsular area shows rounded outlying and gentle slopes, except where the outcrop of hard or massive beds has led to the formation of scarps; the gradients of the streams are flat, their beds sandy, and seldom do they show signs of active erosion of their channels; in fact, the Peninsular area shows all the features of an ancient land-surface, long exposed to subaerial denudation, in which the streams and hill-slopes have alike gone far towards reaching a condition of equilibrium.

The Himalayas, on the contrary, are a region of deep, steep-sided, valleys and gorges; nearly everywhere the streams and rivers alike are torrents flowing over a bed of coarse boulders, everywhere, with but local exceptions, they are evidently eroding their channels, while the steep slopes and sharp crests of the ridges, no less than the constant landslips and general instability of the soil, betoken a country in which the action of rain and frosts on the hill-sides has not been able to keep pace with the deepening of the stream-beds by erosion.

Equally striking is the contrast in the nature of the boundary of the two areas with the Indo-gangetic alluvium. To the north the Himalayas rise abruptly from slopes of recent gravels at their base, and, though there are irregularities of detail, the boundary as a whole sweeps in a crescent curve from one extremity to the other, while there are no outliers of the Himalayan beds surrounded by alluvium, nor are there any long tongues of the latter running up into the Himalayan area. To the south the rocks slip imperceptibly under the alluvium, so much so that different observers have differed by miles in the boundary they drew between the alluvium and the older rock; the boundary exhibits every variety of irregularity, long tongues of alluvium run up the various river valleys far into the rock area, and, to crown all, there are outliers innumerable of the peninsular rocks standing up from the alluvial plain.

These last contrasts between the two areas are shown even on a good topographical map; but that now to be mentioned, the most important of all, can only be seen on one that is geologically coloured.

Along its southern boundary the alluvium is in contact with rocks of various ages; but to the north, with the exception of a short distance in Sikkim, a zone of rocks of Tertiary age separates the alluvium on the one hand from the pre-Tertiary rocks of the Himalayas on the other. In a word, the southern boundary is due to the freaks of denudation and alteration of level, while the northern is a structural boundary; and this will be made still more evident when we come to consider in more detail that band of Tertiary deposits which forms the southern margin of the Himalayas, and has so important a bearing on the subject with which this paper deals.

Part I. The Facts.

The Tertiaries of the outer Himalayas present a marked similarity of type along the whole extent of the range, but the sequence is not everywhere equally complete. In the extreme north-west there is a great series of beds, ranging from the marine Nummulitics at the base to the subaerially deposited Pliocene conglomerate sandstones and clays at the summit. They were divided by Mr. Wynne, who examined this country, as follows:[1]—

1. Upper Siwalik, about 4000 feet; brown drab or reddish clays, soft grey sandstones, conglomerates.
2. Lower Siwalik, about 10,000 feet; soft grey sandstones and brown and grey clays, many red clays.
3. Murree beds, average 7500 feet; harder grey sandstones with soft zones, red or purple clays.
4. Nummulitic, upper 800 feet; greenish grey and purple sandstones, grey, olive-brownish, red and variegated clays with masses of gypsum.
5. Nummulitic limestones with shales and coal at base.

The series is said to be parallel and conformable from the pale limestones upwards to the top of the Siwaliks.

The series in the Jamu[2] (Jummoo) hills appears to be practically the same, except that the Nummulitic Limestone is much less developed.

In the Simla region the Tertiaries are divided into two distinct areas, in which the beds are of different ages, though they may slightly overlap each other. The first area forms part of the lower Himalayas and the beds constitute the so-called Sirmur series, divided into

1. The Kasaoli group; grey sandstones, sandy shales, and shales containing plant-remains.
2. The Dagshai group; hard, fine-grained sandstones and red or purple nodular shales, the former prevailing in the upper and the latter in the lower part of the group.

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[1] Records Geol. Surv. India, vol. x. p. 112 (1877).

[2] Mem. Geol. Surv. India, vol. xxii. chap. v. (1883).

3. The Subathu group; olive green, grey and red shales and subsidiary bands of sandstone and argillaceous limestone, with a coal-seam and a peculiar ferruginous bed at the base. It contains Nummulites and other marine fossils.

The second area, forming part of the sub-Himalayas, is divided from the Sirmur series by a great fault, and, in many places, by a narrow strip of pre-Tertiary beds; the series may be divided as follows:

1. Upper Siwalik; soft sandstones or sandrock, conglomerates and some clays.
2. Lower Siwalik; soft sandstones or occasionally pebbly sandstones, and clays mostly grey, but sometimes tinged with red, especially in the lower part of the group.
3. Nahan group; firm or hard sandstones interbedded with clays generally nodular and of a bright red colour, which are more abundant in the lower part of the group than in the upper.[1]

The series in the two areas combined appears to be much the same as in the Murree hills. The Nummulitic Limestone is not developed, and the marine deposits are much less in thickness; but there can be no doubt that the Subathu group represents the Nummulitic groups of Mr. Wynne. The Dagshai and Murree groups correspond so closely in mineral character and stratigraphical position that there can be no risk of error in correlating them, while the two upper groups in the north-west are evidently the equivalents of the three groups in the sub-Himalayas of the Simla region and possibly in part of the Kasaoli group of the Sirmur series.

To the east of the Ganges there are a few small outliers of the Subathu group faulted and folded among the pre-Tertiary beds near their southern boundary; but with this exception the only Tertiary beds known here or to the eastwards are confined to the Nahan and Siwalik groups.[2]

Besides these Tertiaries of the Outer Himalayas, beds of the same age are known to exist at several places to the north of the main snowy range; but it is only in Cashmere territory that they have been examined in any detail. In the Upper Indus Valley the Nummulitics may be briefly described as consisting, at the base, of coarse-grained sandstones, arkose beds and conglomerates, considered by Mr. Lydekker to be of glacial origin; they are certainly of littoral origin, and indicate the close proximity of the original limit of deposition. Above these come red, and green and grey shales, of very similar type to those of the Subathu group, interbedded with limestones; while at the top the series consists of a great thickness of beds, mainly volcanic in their origin and basic or ultrabasic in composition.[3]

The coarse-grained beds of littoral origin are confined to the north-eastern boundary of the exposure, whose south-western boundary is marked by great disturbance, and is in effect a faulted one. It seems then that to the north-east the original limit of deposition was not far removed from the present boundary, but to the south-west there is no indication of the original limit of deposition; and the small outlier in the Singhe La, between Zanskar and the Indus Valley, is described by Mr. La Touche as consisting of a fœtid limestone, resting directly on the Secondary quartzites without the intervention of any beds of a littoral or shallow-water origin.[1] From this it is evident that the land-surface must have been far to the southwards, and it may be that the sea extended over the whole of the Himalayan area between this and the outcrops of the Subathu group, as it certainly must have done over a considerable portion of it.

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[1] Comp. Medlicott, Mem. Geol. Surv. India, vol. iii. part 2, chaps. i. and iii.; also Manual of Geology of India, vol. ii. chap. xxii.

[2] Oldham, Rec. Geol. Surv. India, vol. xvii. p. 161 (1884); Middlemiss, Mem. Geol. Surv. India, vol. xxiv. part. ii. 1890.

[3] Mem. Geol. Surv. India, vol. xxii. chap. v.

Having briefly reviewed the geology of the Himalayas so far as is necessary to make what follows intelligible, we must now enter into a detailed consideration of the evidence. It is not, however, intended to give here anything resembling a complete account of the geology of the Himalayas, for such would be impossible in the space available, but merely to notice such points as have a special connection with the age and elevation of the Himalayas.

The first, most important, most palpable and unmistakeable point that stands out is that, at the commencement of the Tertiary period, the Himalayas did not exist as a distinct mountain range, or at least that, if the Himalayan system of disturbance had commenced, it had not extended north-west of a line, drawn transverse to the range, through the debouchure of the Ganges. This is amply proved by the occurrence of marine nummulitics in the heart of the Himalayas, in the Upper Indus Valley and in Zanskar, at heights of 19,000 to 20,000 feet above the level of the sea.

But besides this the nature of the contact between the Nummulitic and pre-Tertiary beds points to the same conclusion. In the Upper Indus Valley the Nummulitics rest directly on an eroded surface of, presumably, Archæan gneiss; in the outer hills, however, they rest on limestones or slates, and Mr. Medlicott has noticed how, both near Subathu and in the Jamu Hills,[2] wherever the boundary is one of original contact, there is no perceptible divergence of dip between the Tertiary and pre-Tertiary formations. The same appears to be the case with the outliers in Garhwal, and this shows that, though the older rocks had been denuded before the Nummulitics were deposited, they had not at that time been seriously disturbed, and that their position was practically one of horizontality.

It is true that, in his recently published memoir, my colleague, Mr. Middlemiss, has shown good reason for believing that, at the commencement of the Tertiary period, the pre-Tertiary beds were not everywhere so slightly disturbed as the contact with the Nummulitics would indicate.[3] But the Himalayan area is a large one, and it would be unnatural to suppose that there had been no disturbance of any part of it before the commencement of the Tertiary period; while the evidence produced by Mr. Middlemiss shows that the pre-Tertiary disturbance was transverse, and did not belong to that which has resulted in the elevation of the Himalayas. It may be that in Kumaon and Garhwal this last had already commenced when the Nummulitics were being deposited and only extended to the north-west at a later period; but there is no evidence to show that it could have commenced before the end of the Secondary period; and the early Palæozoic or still earlier date, to which Mr. Middlemiss would seem inclined to refer the first origin of the Himalayas as a mountain range, is, to say the least, extremely improbable.

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[1] Rec. Geol. Surv. India, vol. xxi. p. 161.
[2] Rec. Geol. Surv. Ind. vol. ix. p. 54.
[3] Mem. Geol. Surv. Ind. vol. xxiv. p. 184.

Besides the stratigraphical evidence of the absence of disturbance, there is everywhere, from the Jamu Hills to the outliers east of the Ganges, a peculiar pisolitic, ferruginous bed, which invariably occurs at the base of the Subathu group. In mineral and chemical character this closely resembles the laterite of the Peninsula and the laterite beds, which occur interbedded with the Nummulitics of Cutch and Sind, and must probably be referred to the same source of origin. The origin of the laterite of the Peninsula is still a vexed question, which has been much complicated by the very loose manner in which the term has been used; but the balance of evidence seems to show that the true laterite is in some way or other connected with the Deccan Traps, and is directly or indirectly the result of an alteration of them or their detritus. If this same source of origin is accepted for the ferruginous bed at the base of the Subathu group, it follows that the present distinction between Peninsular and Extra-peninsular areas had not been established in Eocene times, and, consequently, that the system of disturbance of which it is the result must, at the outside, only have commenced when the Subathu group was being deposited.

In this connection the occurrence of Gondwana rocks of Peninsular type in Sikkim and the Eastern Himalayas is important. Unfortunately nothing is known of the great area of Nepaul, which occupies the middle third of the length of the Himalayas; but Sikkim cannot in any way be regarded as a terminal area, and the occurrence of Peninsular beds of latest Palæozoic or early Secondary age[1] shows that the present limits between the Peninsular and Himalayan areas cannot have been established until the Secondary period at the earliest.

A further insight into the history of the commencement and progress of the elevation of the Himalayas may be derived from a study of the structure of the sub-Himalayan ranges.

In the region west of the Jhelum the structure of the ground does not enable us to decide with certainty at what date the Himalayan system of disturbance invaded that area; but, so far as can be judged, the beds appear to have undergone but little compression till towards the end of the Tertiary period.

In the Jamu Hills we find the typical sub-Himalayan structure has commenced, though not so fully developed as further to the south-east. Next to the pre-Tertiary rocks of the Himalayas proper comes a broad zone, principally formed of the Murree group, at the outer margin of which rise some inliers of pre-Tertiary (Carboniferous?) limestone, overlaid by the marine Subathu group, while near the inner boundary, with the pre-Tertiary rocks, there are some outliers of Upper Siwalik clays and conglomerates. The general section from S.W. to N.E. is therefore an ascending one, and both boundaries of this zone are, in effect, great faults with an upthrow on the Himalayan side. Between this zone of Murree beds and the alluvium of the plains there comes a band of Upper Tertiaries, which, on the only published maps, are divided into an inner, older, and an outer, newer zone; but there is no indication of the nature of the boundary.

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[1] Mallet, Mem. Geol. Surv. India, vol. xi. part i.; see also Godwin-Austen, Journ. Asiatic Soc. Bengal, part ii. vol. xxxviii. p. 151; La Touche, Records Geol. Surv. India, vol. xviii. p. 121.

After leaving the Jamu Hills, the zone of Lower Tertiaries becomes much restricted in width, till we reach the Simla region. Here the Lower Tertiaries, forming the Sirmur series, are distinctly separated from the Upper Tertiaries or Nahan and Siwalik groups. The boundary is a great reversed fault, and along nearly the whole length of it the two divisions are not in contact, but separated by a band of pre-Tertiary slates and limestones. The beds of the Sirmur series have partaken of the intense disturbance of the pre-Tertiary beds, with which they are folded up in the most complicated manner, and the northern boundary is no longer a single well-defined fault, to the north of which there are no outliers. But the most important point to notice is that in the area occupied by the Sirmur series there is no trace of the Upper Tertiary groups, which were either never deposited or have been completely removed by denudation.

Still further to the south-east, the small outliers in Garhwal only exhibit the remains of the Subathu group, no representative of the two Upper groups of the Sirmur series being found.

The explanation of these facts, which has been adopted by every observer of the ground in question, is that the disturbance of the Himalayas gradually advanced from S.E. to N.W., and that the missing upper groups were never deposited over the outliers owing to the elevation resulting from this disturbance. There is ample corroborative evidence to prove the truth of this hypothesis; but the same result is arrived at even if we suppose that the full sequence of deposits was formed everywhere alike, for the condition of the Simla area is such as would result from a greater elevation and denudation of the Jamu area, while the outliers in Garhwal might result from a still further extension of the same processes. But as both elevation and denudation take time, and as the conditions of the three areas with regard to denudation at least are substantially similar, we reach the same conclusion as before, that the elevation, and consequently the denudation of the Garhwal area must have commenced before that of the Simla area, and this again before that of the Jamu Hills.

Before passing on to a consideration of the evidence of the

Siwalik groups, it will be well to briefly examine the nature and distribution of the deposits now being formed along the foot of the Himalayas. Along the outer margin of the hills there is everywhere a zone of gravel and boulder deposits; near the debouchure of the great rivers this consists of well-rounded fragments of crystalline rocks, quartzite, and some limestone; where there are no large rivers, the fragments are less rounded, and consist of the rocks exposed within the drainage-area of the streams flowing down from the hills. The similarity of these gravels to those brought down at the present day, and the fact that their diversity is matched by that of the gravels of the existing streams, leaves no room for doubt that they deposited the gravels even in those districts where they have since cut deep channels through their old deposits.

Outside the zone of boulders and gravel comes a region of sands, of various degrees of fineness, and outside this again the clays and fine silts which form the bulk of the Gangetic alluvium.

It must not be understood that this division into three zones is absolute. Sand and clay are occasionally found close up to the foot of the hills, even near the debouchures of the great rivers, but none the less it truly represents the general disposition of the recent deposits. The width of the zones is not constant, and the boulder and gravel zone in particular expands opposite the debouchures of the great rivers. With all these local variations the main fact remains, that on any line drawn transverse to the boundary of hill and plain, the deposits, omitting minor variations and local exceptions, decrease in coarseness as we pass away from the hills, that the coarse deposits of gravel and boulders are confined to the immediate neighbourhood of the boundary, and that it is only near the debouchure of the principal rivers that these are composed of large and well-rounded fragments of hard crystalline and metamorphic rocks.[1]

Returning now to the Siwalik deposits, we find that the same relation between the composition of the gravels and the existing drainage system which is exhibited by the recent deposits of the northern margin of the plains, has also been noticed by every observer in the conglomerates of Upper Siwalik age.

In the neighbourhood of the Jumna and Ganges rivers we find a great development of conglomerates, composed of well-rounded boulders of crystalline and metamorphic rocks. East of the Ganges, there comes a tract where the watershed is only a few miles removed from the edge of the hills, and coincident with this there is a narrowing of the Siwalik zone, and a cessation of the thick deposits of sandstone and conglomerate, till the Ramganga and Kosi rivers are reached. Here the Siwalik beds again attain a great width and thickness, and there is a large development of conglomerates.[2]

In the country between the Ganges and the Jumna the conglomerates are largely developed and extend for some little distance west of the Jumna: but further west, in the country south of Nahan, the conglomerates not only decrease in thickness, but change their character. The well-rounded boulders of crystalline rocks cease, and, in their place, we find imperfectly rounded fragments of limestone, slate, and quartzite derived from the Lower Himalayas, mixed with a large proportion of fragments of Lower Tertiary sandstones.

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[1] Boulder gravels composed of well-rounded blocks of hard rock are also found in the beds of streams draining from the Upper Siwalik conglomerates; but such exceptions are obvious.

[2] Middlemiss, Mem. Geol. Surv. India, vol. xxiv. pt. 2.

Where the Sutlej passes out through the Siwalik area, there is again a large development of Upper Siwalik conglomerates and the same features of a prevalence of conglomerates near the great rivers, and their absence away from them, continues all the way to the Jhelum.[1]

This peculiarity in the distribution of the Siwalik conglomerates shows that not only are the Siwalik beds of subaerial origin; but that, when they were formed, the Himalayas existed as an elevated region whose main features of hydrography had already been marked out, and further the occurrence of coarse conglomerates, which could only have been deposited in the immediate neighbourhood of the limit of hill and plain, shows that the southern margin of the former must at that time have been approximately the same as the present boundary between the rocks of the Himalayas and of the Siwalik series.

Taking all these considerations into account, the conclusion becomes inevitable that the Siwalik beds were deposited subaerially and under conditions similar to those of the recent deposits along the foot of the Himalayas; that the latter existed as a mountain range, comparable to that now existing, in which the main features of its hydrography had already been marked out; and consequently that the original northerly extension of the Siwaliks cannot have very far overstepped their present northern boundary.

The thickness of these subaerially formed beds varies considerably, but is always great; from ten to twenty thousand feet and perhaps more in places; and as they now, after having been compressed, disturbed and elevated, do not occur at a height of more than a few thousand feet above the sea, it is evident that they must have been deposited in an area of continuous subsidence, which approximately kept pace with the deposition. On the other hand, the Himalayan area, as I shall subsequently show, has been in a state of continuous elevation throughout the Tertiary period, and this elevation has more than kept pace with the denudation of the surface. We have consequently two parallel regions, one of elevation accompanied by denudation; the other of deposition accompanied by subsidence, and we will now investigate the nature of the boundary between them.

Everywhere along the Himalayas the present boundary, between the Upper Tertiary beds and those of pre-Tertiary age, is a gigantic reversed fault. It is one of the most conspicuous structural features of the Himalayas, and, except for the outliers of Lower Tertiary beds in the Simla district and in Garhwal, and the inliers of pre-Tertiary rocks in Jamu, forms an absolute line of demarcation between the Tertiary and pre-Tertiary formations. In Mr. Medlicott's memoir this great fault was called the "main boundary"—a name which has been found so convenient that it has frequently since been used in the publications of the Geological Survey of India, and will be retained here in the sense indicated above.

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[1] Medlicott, Rec. Geol. Surv. India, vol. ix. p. 57.

This main boundary fault is almost everywhere a clean cut fracture, generally reversed, and as a rule the rocks on either side show little or no signs of that crushing which one would expect to have accompanied so great a displacement. As we have seen, it marks, approximately at least, the limit between what was, in Siwalik times, an area of subsidence and an area of elevation, and it is not unreasonable, on this ground alone, to suppose that it was the actual boundary, and formed *pari passu* with the deposition of the beds to the south.

But the main boundary is not the only fault of its kind, though the most remarkable; for, both in the Himalayan and sub-Himalayan areas, there are similar great faults with an upthrow on the Himalayan side, which have been held to mark successive stages in that southerly advance of the margin of the hills, which is sufficiently proved by the elevation of the Siwalik beds, originally deposited in the plains along the foot of the Himalayas.

This supposition derives considerable support from a consideration of the nature of the boundary between the disturbed Upper Siwaliks and the recent deposits of the plains. With a few exceptions where uppermost Siwalik conglomerates dip towards and under the recent gravels, the boundary is a well-defined one, and the undisturbed recent gravels are in contact with disturbed sandstones from which several thousand feet of overlying strata have been removed by denudation. There are no great irregularities of the boundary or deep embayments of the recent deposits, such as would result from a subsidence of the hills and an encroachment of the recent deposits, such, in fact, as are seen on the southern margin of the alluvium. The beds of which the hills are formed are precisely similar in character, and were deposited under circumstances identical with those of the present submontane deposits; and this, taken in conjunction with the outline of the boundary, leads one naturally to the conclusion that the latter is a structural one, and that the hills have slowly and contemporaneously been undergoing elevation and denudation. At the same time the greater bulk of the débris washed down from them has been deposited near their foot, and, to make room for this vast quantity of débris, the latter area must have been slowly subsiding. We have consequently, in close contiguity with each other, an area which has been subject to elevation, and one which has been subject to depression, the boundary between the two being necessarily analogous to those faults with an upthrow to the north which intersect the sub-Himalayan region, and to the great boundary fault which limits it on the north.[1]

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[1] This question is more fully treated by my colleague, Mr. Middlemiss, in his recently published memoir, Mem. Geol. Surv. Ind. vol. xxiv. pt. ii.

In all the sections of the sub-Himalayan beds there is a marked and steady increase in coarseness of texture as we ascend the section. This feature is everywhere observable in the sub-Himalayan sections, and even in the Sirmur series of the Simla Hills there is a steady increase in the proportion of sand to shale from the purely argillaceous Subathu group to the chiefly arenaceous Kasaoli group. This gradual upward increase in coarseness of texture on any one section is an inevitable result of the gradual southward extension of the hill area; for by it the region of fine-grained silts is brought within reach of the sand, and, finally, of the shingle deposits. But besides the increase in coarseness of texture on each section, it is an indubitable fact that the texture of the coarsest beds of each group or division increases with its decrease in age, and this appears to me to be due to a gradual increase in the average size of the debris brought down by the Himalayan streams.

I have already shown that in Eocene times the North-West Himalayas did not exist, and that in Siwalik-Pliocene times there was a mountain range whose hydrography agreed with that of the present day in its main features, and that, to judge by the nature of the burden carried by the rivers, this range must have been comparable in elevation and extent to the present Himalayas. During the Tertiary period, then, the Himalayas were in process of elevation, and it is natural to suppose that, during the earlier part of this process, the gradients of the streams and their powers of transportation would be less than at a later period, and that, consequently, no great deposits of coarse gravel could be found. This supposition derives great support from the fact that throughout the great thickness of the Dagshai and Kasaoli groups, and of the Murree group, not a single pebble has been found, while with one very doubtful exception[1] no conglomerates of Nahan age are known.

In the foregoing passages it has been tacitly assumed that elevation has always been accompanied and caused by disturbance of the beds elevated, and such, in the main, is the case. There are, however, recent undisturbed gravels which rise, in the sub-Himalayan region, to heights of 500 feet above the present river-beds and seem to indicate that there has been a certain amount of elevation unaccompanied by disturbance of the horizontality of the beds elevated. So, too, the fossiliferous Pleistocene deposits of Hundes have probably been elevated without disturbance to some extent, though not so much as was supposed by the earlier observers.[2] With these subsidiary exceptions, which do not affect the general principle, it is true that, in the Himalayas, elevation has always been a result of the compression and disturbance of the beds elevated.

[1] Mem. Geol. Survey India, vol. iii. part ii. p. 135.

[2] Lydekker, Rec. Geol. Survey of India, vol. xiv. pp. 178–183 (1881).

(*To be continued.*)

III.—The Motion of Land-ice.

By J. G. Goodchild, F.G.S., of H.M. Geol. Survey,
Lecturer on Geology and Palæontology at the Heriot-Watt College.

AMONGST the many useful tables given in Prof. Prestwich's "Geology" is one on the expansion and contraction of ice under variations in temperature (vol. i. pp. 139 and 183). The table in question is abbreviated from one of greater length, which was published in the year 1845 by Carl Brunner von Wattenwyll in the *Annales de Chimie et de Physique*, 3^{me} ser. tome 14, pp. 369-378, under the title of "Expériences sur la densité de la glace à différentes températures." The author of the paper referred to made an extensive series of observations upon the contraction of ice under various temperatures below the freezing-point; and he proved conclusively that, under these circumstances, the contraction of ice exceeds that of all other solid bodies that had (up to the date of the paper) been studied in this connection. Taking the density of pure water at 0° Centigrade as unity, then the contraction in question for a fall of each degree Centigrade is expressed by the decimal figures in the right-hand column of the following table (*op. cit.* p. 378):—

Temperature.	Density of Ice.	Temperature.	Density of Ice.
0° Centigrade.	0·91800	—11 Centigrade.	0·91924
—1	0·91812	—12	0·91935
—2	0·91823	—13	0·91946
—3	0·91834	—14	0·91957
—4	0·91845	—15	0·91968
—5	0·91856	—16	0·91980
—6	0·91868	—17	0·91991
—7	0·91879	—18	0·92002
—8	0·91890	—19	9·92013
—9	0·91901	—20	0·92025
—10	0·91912		

In connexion with this table the author adds that the mean contraction for a fall in temperature of every degree Centigrade is 0·0000375, or $\frac{1}{26700}$.

If the density of the ice increases from 0·91800 at the freezing-point to 0·92025 as the temperature falls to —20° Centigrade, then, of course, the density will diminish, or, what is the same thing, the bulk will increase, proportionately, as the temperature of the ice rises.

M. Brunner's testimony does not stand uncorroborated; for Prof. Prestwich adds to his summary of the paper (Geology, vol. i. pp. 139, 140) some important observations by Dr. Rae upon the ice of the Arctic American lakes, which bear upon the same question. These observations prove, beyond the possibility of doubt, that ice does contract greatly under low temperatures; and, also, that as the temperature rises towards zero Centigrade, the ice does undergo a corresponding increase in volume.

Professor Prestwich, in summarizing the results of these observations, points out the importance of their bearing upon theories of glacier motion; but in doing so he takes into account the effects of changes of temperature of ice arising only from what one may term subaerial causes. These causes, diurnal, or seasonal, etc., variations of temperature must, of course, play a very important part; but their effects are most marked at or near the surface, and cannot directly affect the movements of the lower parts of the ice to any appreciable extent.

But differences in temperature of large bodies of land-ice are not by any means necessarily connected with the effects of solar heat, or of other causes acting from the upper surface of the ice downwards. However low the surface temperature of a thick mass of ice may fall, its internal temperature will not everywhere be the same as at the surface. Observation and experiment alike have proved that the cold-waves (those below 0° Centigrade) affect the surface layers most, and that their effects become less and less marked as the cold-waves are propagated further into the ice. Eventually, the cold-waves travel downwards to a zone where they hardly lower the temperature of the ice at all. The position of this zone in relation to the surface varies, of course, with the degree of cold prevailing at the particular place under observation. There is thus within every thick mass of land-ice a zone below which diurnal or seasonal variations of temperature may be said to produce no appreciable effect. Above that zone, when the temperature falls below the freezing-point, contraction takes place. Where the cold is most felt, *i.e.* at the surface, the contraction is greatest, and there the ice snaps, unless the downhill flow of the adjoining ice at a higher level is sufficient to relieve the tension. From the surface such cracks extend downward, gradually diminishing in width as the downward effects of the cold-waves diminish, until they die out altogether and terminate downward in unbroken ice. Water flows into the cracks, freezes, and the expansive force thus exerted helps to thrust forward the ice on the downhill side, or wherever else may happen at that spot to be the direction of least resistance; and in this way the ice is made to flow. A rise of temperature brings about a general expansion of the upper part of the ice, and, consequently, also forces it to flow in the direction of least resistance from this cause as well as from the others.

But a flow of the surface layers of ice—extending downward at the most perhaps not more than a few hundred feet—will hardly satisfy the requirements of those geologists who are familiar with the effects of ice-action in well-glaciated regions. Every field-geologist who has spent many years in, say, North Wales, the North West of England, or in Scotland, must feel that, somehow or other, the bottom of the Ice-sheet must have flowed, and must have moved steadily, and with nearly-uniform directions of movement, long enough to admit of the stone-shod sole of the Ice-sheet scoring deep and wide grooves upon the surfaces of even the toughest of rocks. M. Brunner did not follow up his researches; but his conclusions should do much to convince even those who are not field-geologists that the lower parts of masses of land-ice really do move forward, and are therefore quite competent to score the rock-surface over which they pass, and to score it to almost any extent.

Let us consider what happened with any of the larger affluents of the Ice-sheet in, say, North West Yorkshire, or in Cumberland and Westmorland. During the Glacial period every one of the valleys in those parts was filled to the brim with masses of ice, which, in most cases, can be shown to have moved outwards from the mountain centres towards the lowlands. The inland and uphill movements, which affected certain parts, were exceptional, and took place only at or near the climax, just before the Ice-sheet began to melt away, and long after most of the glacial erosion had been accomplished. There is reason for believing that for a long period the thickness of the ice in places was not less than two thousand feet. All the rock previously carried seaward by subaerial denudation from those valleys was thus replaced, as it were, by a solid mass of other material,—ice. Doubtless, in those days, as is the case with the smaller glaciers of to-day, the surface layers were slowly impelled downhill and seawards by the alternate expansion and contraction of the ice, aided by the expansive action of water freezing in crevasses, as well, of course, by the pressure of the higher masses of ice behind. All these forces, acting separately or in combination, tend to make the line of swiftest flow coincide with the centre line of the upper layers of each stream.

The tendency to flow most rapidly nearest the surface is, however, counteracted by other causes. Every one seems to have overlooked the fact that when a deep valley is filled by ice, that ice tends to act in much the same way in conducting terrestrial heat outwards towards the surface as if there were rock there in the valley instead of ice. The isogeotherms in such a case, instead of following nearly the contour of the valley as they would do if the ice were absent, would be carried to a higher level, whose exact position would vary with the thickness of the ice and with the surface-temperature for the time being. In other words, the lines of equal subterranean temperature of the rocks forming the sides of the valley would enter the adjoining ice itself, and would connect the isogeotherm of one side of the valley with its corresponding line on the other by a downward curve, which would run through the lower part of the ice, instead of through the rock below upon which it lay.

While the surface-temperature and the terrestrial-temperature were alike in degree, it seems possible that there might be no movement of the ice at all, except that due to the downhill impulse derived from heavier masses at a higher level. Where the surface conditions were such as those described near the commencement of this paper, then the locus of swiftest flow tended to the surface. But when, as must generally have happened during the Glacial period, the surface of the ice was kept in a prolonged state of contraction through extreme cold, the higher temperatures prevailing in the parts of the ice nearer the bottoms of the valleys caused the ice there to expand more than the colder ice overlying, and therefore to move in the direction of least resistance. That direction of least resistance must, under these circumstances, usually remain near the bottoms of the valleys, and it must tend to be modified (1) by the form of the surface adjoining; (2) by the position of the main feeders of that particular ice-stream; and (3) by the situation of the terminal portions of the glacial stream itself.

Another factor comes in here. The movement of a thick mass of ice under enormous pressure (25 tons per square foot for every thousand feet of thickness of ice) must result in the conversion of part of the force so exerted into heat. This in its turn brings about a still further expansion of the parts of the ice in direct contact with the rock, and thus contributes still further to the erosion that is being accomplished by these means. Indeed, it appears to me more than likely that, when once the movement of the lower strata of the ice is set up, terrestrial radiation on the one hand, and the heat generated by the enormous friction on the other, tend to impel the sole of the ice forward with much more regularity, and with much greater evenness of motion, than can be shown to obtain in any part of the surface of any glacier that has yet been carefully examined.

It appears to me that this view of the causes that determine the flow of land-ice will enable us readily to understand the origin of many phenomena of denudation which northern field-geologists have long agreed to refer to glacial action, although no one has explained satisfactorily how those results were accomplished. Lake basins; the remarkable terraces and scars of Wensleydale, etc.; the corries or coums so characteristic of glaciated districts; the great glacial ruts so well seen near Appleby, for example, or near Edinburgh, can each and all be readily enough accounted for if we extend M. Brunner's observations to their proper conclusion, and assume that the flow of a large mass of land-ice is not limited to its upper parts, but extends also to the bottom layers in contact with the rock.

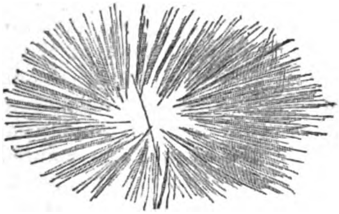
IV.—NOTES ON A NEW FOSSIL SPONGE FROM THE UTICA SHALE FORMATION (ORDOVICIAN) AT OTTAWA, CANADA.

By GEORGE JENNINGS HINDE, Ph.D., F.G.S.

MR. H. M. AMI, F.G.S., of the Geological Survey of Canada, who has devoted special attention to the fauna of the Utica Shale in the neighbourhood of Ottawa, lately sent me for examination several fragments of slabs of this rock containing some peculiar sponge remains, which seem to me to be worthy of notice, although, from their mode of preservation, no decisive determination as to the character of the sponge to which they belong can be arrived at.

The fossils in question appear to the naked eye as so many circular, or, in some instances, fan-shaped, faintly-marked rusty patches on the surface of the black shale, each consisting of delicate lines or markings radiating from a centre. These patches are so numerous as in places to cover the surface, and their margins overlap each other, so that their individual outlines cannot in all cases be distinguished; further, it can be seen that they are not limited to a single surface layer, for the rock to the thickness of about a millimètre consists of several distinct successive films or layers, each covered with similar rusty patches of radiating lines. Examined with a lens or under a microscope, these lines are seen to be in reality very fine, delicate needle-like spicules radiating horizontally from a centre. The spicules are not all of the same length, so that the outer margin of each patch is uneven, and the general appearance of these circles impressed on the rock-surface calls to mind the nimbus or halo which in old religious books is depicted round the heads of saints.

The circular patches are from 18 to 24 mm. in diameter; the spicules of which they are formed are straight, simple, apparently smooth, and nearly of an even thickness throughout their length, which appears to be from 8 to 10 mm., whilst they are only about ·035 mm. in thickness. In some instances the spicules radiate from the centre of the patch, in others there is a small free central space, and occasionally they are disposed in the shape of a fan. In all cases the spicules form an extremely thin layer. The spicules are for the most part pyritized, in some instances they are reduced to rusty peroxide. This change of the original silica to pyrites and peroxide of iron seems to be of very general occurrence wherever siliceous sponges have been preserved in black bituminous shales; well-known instances are those in the Cambrian shales of St. Davids, South Wales, and those lately described by Sir J. W. Dawson from the black Ordovician shales at Métis, Lower St. Lawrence (Trans. Roy. Soc. Canada, vol. vii. 1889, p. 31).



***Stephanella sancta*, gen. et sp. nov.; Utica Shale (Ordovician), Ottawa, Canada.**

It may be taken for granted that each of the numerous circular patches in this rock indicates the basal portion of a distinct sponge; but it is hardly likely that it represents the entire skeleton of the organism, and it is insufficient to determine conclusively the nature of the sponge. It has been suggested by Sir J. W. Dawson,[1] who has seen some of the specimens, that they may be the root-spicules of Hexactinellid sponges. As a rule, however, the anchoring-spicules in this group of sponges consist of a more or less compact bundle of elongated spicules which extend downwards from the base of the sponge and anchor it in the mud, consequently very different from the horizontal radial disposition of the spicules in these specimens. Further, if they were the anchoring appendages of hexactinellid sponges, one would naturally expect to find some traces of cruciform or typical six-rayed spicules characterizing the bodies of these sponges, more particularly as the great regularity in which the free radial spicules forming these circular patches have been preserved in their natural position indicates the absence of currents to remove the body-portions from their bases. But on the slabs I have examined, I do not recognize any distinctive hexactinellid spicules. At the same time it is not altogether impossible that these fossils may be a peculiar modification of the anchoring appendage of hexactinellid sponges, and this view derives some support from the fact that a species of this group, *Cyathospongia reticulata*, Walcott, sp., occurs in this Utica Shale, though Mr. Ami has not yet discovered any specimen of it in the vicinity of Ottawa.

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[1] Notes on Specimens, Peter Redpath Museum, 1888, p. 59.

There are however certain recent siliceous Monactinellid and Tetractinellid sponges, inhabiting deep water, which possess basal structures of slender radiating spicules, very similar in character and arrangement to those forming these fossil impressions. Thus in the genus *Radiella*, O. Schmidt[1] (=*Trichostemma*, Sars[2]), there is a basal layer of long straight, styliform or pin-shaped spicules radiating from a centre and forming a definite fringe round the sponge, whilst the spicules of the body of the sponge are smaller and less likely to be preserved as fossil. Again in *Tethya casula*, Carter,[3] there is a well-marked basal fringe of spicules, but in this case the spicules have trifid head-rays and consequently differ in character from those in our fossils. As pointed out by Sars, and more particularly by Ridley and Dendy,[4] the basal fringe of elongated spicules in these sponges serves not so much to anchor the sponge as to support it on the surface of the soft yielding mud of the sea-bottom.

There seems fair ground for supposing that these patches of radiating spicules likewise served as basal supports to sustain the sponges, which lived in dense colonies, on the surface of the ooze. Whether these sponges were hexactinellid or monactinellid must for the present remain an open question; but it may be desirable to give a name to them, and I propose to call them *Stephanella sancta*.[5]

The specimens were collected by Mr. H. M. Ami from the Utica shale, at Ottawa itself, and in the adjoining township of Gloucester.

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[1] Spongien Fauna Atlantischen Gebietes (1870), p. 48, pl. 4, fig. 6.

[2] Remarkable Forms of Animal Life (1872), pt. i. p. 62.

[3] Ann. and Mag. Nat. Hist. ser. 4, vol. viii. (1871), p. 99, pl. iv. figs. 1–9.

[4] 'Challenger' Report, Zoology, vol. xx. (1877), p. 216, pl. xliii.

[5] *στεφάνη*, a wreath, dimin.

V.—NOTE ON THE IDENTITY OF *NAUTILUS NEOCOMIENSIS*, SHARPE (*non* D'ORBIGNY) WITH *NAUTILUS DESLONGCHAMPSIANUS*, D'ORB.

By ARTHUR H. FOORD, F.G.S.;
and G. C. CRICK, Assoc.R.S.M., F.G.S.,
Assistant in the Geological Department, British Museum.

IN 1853, in his "Description of the Fossil Remains of Mollusca found in the Chalk of England" (Mon. Pal. Soc.), Sharpe described and figured a specimen under the name of *Nautilus Neocomiensis*, d'Orbigny. He states (*loc. cit.* p. 15), "We have only seen one small specimen from the Grey Chalk, which we can refer to this species; it is from Urchfont near Devizes, in the Collection of Mr. Cunnington, and is 2 inches in its greatest diameter and 1¼ inch in breadth; although a good deal broken, it shows all the peculiar characters of the species. The species is more common in the Lower Greensand of Dorking, Atherfield, Sandgate, etc., where it sometimes reaches above 7 inches in diameter. M. d'Orbigny quotes it as common in the lower beds of the Middle Division of the Neocomian Formation in France."

The specimen referred to is now in the British Museum (No. 88640). It is a natural cast and in its badly preserved state the flexuous ribs appear to be rounded. A close examination of the fossil, however, reveals distinct traces of fine longitudinal lines between the ribs, a character which suggests affinities with *Nautilus Deslongchampsianus*, d'Orbigny. Moreover the remains of the body-chamber, the posterior portion of which Sharpe has represented in his plate v. fig. 3c, show, on either side, at a short distance from the umbilicus, the keel so characteristic of the same species. The area between the keel and the umbilicus is also marked by faint, raised, longitudinal lines. The umbilical portion of the remainder of the specimen is too much broken to show the keel distinctly. The rest of the characters of the specimen, viz., the general form, the form of the sutures and the position of the siphuncle, all agree perfectly with *Nautilus Deslongchampsianus*, and there can be no doubt that the specimen referred by Sharpe to *Nautilus Neocomiensis* is only a small, much-broken and badly-preserved specimen of *Nautilus Deslongchampianus*. The locality and horizon of the fossil also support this conclusion.

ERRATUM—In GEOL. MAG. December, 1890, p. 551, fourth line from top of page, insert *Not* before the paragraph beginning "1853. *Nautilus pseudoelegans*, Sharpe," and ending "figs. 2*a*, 2*b*."

VI.—A CATALOGUE OF BRITISH FOSSIL VERTEBRATA.

SUPPLEMENT FOR 1890.

By ARTHUR SMITH WOODWARD, F.G.S., F.Z.S.,
and CHARLES DAVIES SHERBORN, F.G.S., F.Z.S.

IN the Palæontology of the Vertebrata, so much progress is made in various directions in Britain, that it seems advisable to attempt to bring up to date the record of the subject prepared and published by the writers a year ago. The following list may thus be regarded as the first supplement to the work in question; and it is hoped, by the courtesy of the Editor, to issue such a list of additions annually in the GEOLOGICAL MAGAZINE.

With regard to general corrections it must be remarked, that the memoir of Mr. J. Ward, forming Vol. X. of the Trans. N. Staffs. Inst. Mining Engin., frequently quoted in connection with Carboniferous fishes, was not issued until February 1890, the publication having been delayed by unforeseen circumstances. Mr. J. Weston, of Fenton, should have been mentioned as the collector of a fine series of fishes from the Staffordshire Coal-measures, which will shortly become the property of the British Museum. In connection with the Carboniferous fishes of the Edinburgh Coal-field, the writers also regret to add that they failed to distinguish between the private and public collections made and extended by Dr. R. H. Traquair, as Keeper of the Natural History Department in the Edinburgh Museum. In this case, however, it is not possible to rectify the error at present, there being no list or catalogue of either of these collections.

A few names applied by Owen to London Clay Teleosteans, in the Cat. Foss. Rept. Pisces Mus. R. Coll. Surgeons, were also overlooked; but most of these refer to species already recorded under the MS. names of Agassiz, and it is thus proposed to defer entering them until the synonymy has been investigated.

PISCES.

Acanthodes Mitchelli, Ag.: remarks and outline-figure by Traquair in Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 481, woodc. 2, under name of *Mesacanthus Mitchelli*.

Acanthodes sulcatus, Ag.: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 392, and Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 481, woodc. 1. Fife and Midlothian.

——— *Wardi*, Eg.: Ward, Trans. N. Staffs. Inst. Min. Engin. vol. x. 1890, p. 157, pl. v. f. 2.

Acrodus minimus, Ag.: Portlock, Rep. Geol. Londonderry, 1843, p. 469, pl. xiv. f. 18 (? 17). Rhætic; N. Ireland.

Acrolepis Hopkinsi, M'Coy: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398 (to include *A. Rankini*).

——— *ortholepis*, R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398, and Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 492 (olim *Elonichthys ortholepis*).

——— *Rankini* (Ag.): synonym of *A. Hopkinsi*.

——— *semigranulosus* [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398. Calcif. Sandst.; Straiton. [Scales; Edinb. Mus.]

Anodontacanthus attenuatus [n. sp.], J. W. Davis, Proc. Yorks Geol. Soc. vol. xi. (2), 1890, p. 333. [? *Pleuracanthus*]. Carbonif.; Cultra, Co. Down. [Spine; C. Bulla Coll., Belfast.]

Aspidorhynchus crassus [n. sp.], A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 296, pl. iii. f. 11–15 (includes *A. sp.* (1888), *Belonostomus flexuosus*, and *Sauropsis mordax*).

——— sp., A. S. Woodward: v. *A. crassus*.

Asteracanthus Stutchburyi, Ag.: synonym of *A. verrucosus* (E. Wilson, GEOL. MAG. 1890, p. 366). [Type,–Bristol Mus., probably from Purbeck Beds, Swanage.]

——— *verrucosus*, Eg.: includes *A. Stutchburyi*, Ag.

Belonostomus flexuosus, Phillips: = ? maxilla of *Aspidorhynchus crassus*, A. S. W.

——— *leptosteus*, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 296.

Caturus pleiodus [n. sp.], A. S. Woodward (*ex.* Ag.), Proc. Geol. Assoc. vol. xi. (1890), p. 294, pl. iii. f. 10 (genus uncertain).

Centrolepis, Eg.: A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 430.

——— ***asper***, Eg. (*ex* Ag.): A. S. Woodward, *ibid.* p. 430, pl. xvi. f. 1.

Ceratodus Phillipsi, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 292, pl iii. f. 5.

Chirodopsis Geikiei, Traq.: Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 494.

Chirodus crassus [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 400. Carb. Limest.; Abden and Beith. [Scales; Edinb. Mus.]

Chirolepis Trailli, Ag.: recorded from Achanarras, Caithness, by Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 485.

Coccolepis liassica [n. sp.], [-us], A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 435, pl. xvi. f. 2–4. Lower Lias; Lyme Regis. [Fish; Brit. Mus.]

Coccosteus, Ag.: A. v. Koenen, Geol. Mag. 1890, p. 191.

——— ***decipiens***, Ag.: Traquair, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 125, pl. x. and Geol. Mag. 1890, p. 235.

——— sp., J. E. Lee, Geol. Mag. 1880, p. 146, pl. v. f. 3. U. Devon.; Chudleigh, S. Devon. [Median dorsal plate; Brit. Mus.]

Cœlacanthus Phillipsi, Ag.: J. W. Davis, Geol. Mag. 1890, p. 159.

——— sp. [n.], J. W. Davis, Proc. Yorks. Geol. Soc. vol. xi. (2), 1890, p. 334. Carbonif.; Cultra, Co. Down. [Bones; C. Bulla Coll., Belfast.]

Cosmolepis, Eg.: synonym of *Oxygnathus*.

——— ***Egertoni***, Eg.: v. *Oxygnathus Egertoni*.

Cosmoptychius, Traq.: synonym of *Elonichthys*.

——— ***striatus*** (Ag.): v. *Elonichthys striatus*.

Ctenodus interruptus, Barkas: A. S. Woodward, Ann. Rep. Yorksh. Phil. Soc. 1889 (1890), p. 37, pl. i. f. 2; R. H. Traquair, Geol. Mag. 1890, p. 249. Form. and loc. are Carb. Limest. and Calcif. Sandst., Fifeshire and Midlothian (not English Coal-Meas.)

——— ***Murchisoni***, Ag. MS.: first described by J. Ward, Trans. N. Staffs. Inst. Mining Engin. vol. x. 1890, p. 156. Additional locality is Longton, N. Staffordshire.

——— ***caudatus***, Barkas: v. *Sagenodus caudatus*.

——— ***corrugatus***, Atthey: v. *Sagenodus corrugatus*.

——— ***obliquus***, Atthey: v. *Sagenodus inæqualis*.

——— ***obliquus***, var. *quinquecostatus*, Traq.: v. *Sagenodus quinquecostatus*.

——— ***obtusus***, Barkas: v. *Sagenodus obtusus*.

——— ***octodorsalis***, Barkas: v. *Sagenodus octodorsalis*.

Ctenolepis cyclus, Phillips (*ex* Ag.): A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 301. There is an early fig. of this sp. in C. Prevost, Ann. Sci. Nat. vol. iv. 1825, pl. xviii. f. 21.

Dapedius dorsalis (Ag.): M. Browne, Trans. Leicester Lit. and Phil. Soc. n. s. vol. (1890), p. 196 (includes *Dapedius monilifer*).

——— ***monilifer*** (Ag.): synonym of *D. dorsalis*.

Diplopterus Agassizi, Traill: Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 484, woodc. 3.

Drydenius [n. g.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 399.

——— ***insignis*** [n. sp.], R. H. Traquair, *ibid.* Carb. Limest.; Loanhead. [The type species, founded on jaws, etc.; Edinburgh Mus.]

Elonichthys, Giebel: to include *Cosmoptychius*, Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 396.

——— ***Dunsi***, Traq.: synonym of *E. nemopterus* (Ag.), Traquair, *ibid.* p. 395. [v. *E. Robisoni*].

——— ***intermedius***, Traq.: synonym of *E. nemopterus* (Ag.), Traquair, *ibid.* [v. *E. Robisoni*].

——— ***multistriatus*** [n. sp.], R. H. Traquair, Proc. Roy Soc. Edinb. vol. xvii. 1890, p. 396. Carb. Limest.; Gilmerton and Loanhead [Fragments; Traquair Coll.]

——— ***nemopterus*** [Ag.]: Traquair, *ibid.* p. 394 (to include *E. Dunsi*, *intermedius*, *ovatus*, *Robisoni*, *striolatus*, *tenuiserratus*). [v. *E. Robisoni*.]

——— ***ortholepis***, Traq.: synonym of *Acrolepis ortholepis*.

——— ***ovatus***, Traq.: synonym of *E. nemopterus* (Ag.), Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 396. [v. *E. Robisoni*.]

——— ***Robisoni*** (Hibb.): referred with several other supposed species to *E. nemopterus* by Traquair, as noted above. *Palæoniscus Robisoni*, however, being described by Agassiz before the so-called *Amblypterus nemopterus*, the specific name originally suggested by Hibbert must be adopted.

Elonichthys striatus (Ag.): Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 396 (olim *Cosmoptychius striatus*).

———— *striolatus* (Ag.): synonym of *E. nemopterus* (Ag.), Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 395. [v. *E. Robisoni*.]

———— *tenuiserratus*, Traq.: synonym of *E. nemopterus* (Ag.), Traquair, *ibid.* [v. *E. Robisoni*].

Eogaleus toliapicus, R. Owen, Cat. Foss. Rept. Pisces Mus. R. Coll. Surgeons, 1854, p. 133. London Clay; Sheppey. [Vertebræ; Mus. R. Coll. Surgeons.]

Eurycormus grandis, A. S. W.: A. S. Woodward, Proc. Geol. Soc. 1890, p. 8, and Geol. Mag. 1890, p. 289, pl. x. f. 1–8.

Eurynotus crenatus, Ag.: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 400 (to include *E. fimbriatus*, Ag.)

———— *fimbriatus*, Ag.: synonym of *E. crenatus*, Ag , Traquair, *ibid.*

———— *microlepidotus* [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 400. Carb. Limest.; Loanhead. [Imperfect fish; Traquair Coll.]

Ganodus, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 290, pl. iii. f. 4.

Ganopristodus, Traq.: synonym of *Uronemus*.

———— *splendens*, Traq.: v. *Uronemus splendens*.

Glyptolepis Flemingii, H. Mitchell and J. Powrie: v. *Holoptychius Flemingi*.

Glyptolepis paucidens (Ag.): Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 483.

Gyrolepis Albertii, Ag.: Portlock, Rep. Geol. Londonderry, 1843, p. 469, pl. xiv. f. 12–14 and f. 11 (*G. tenuistriatus*). Rhætic: N. Ireland.

Gyronchus oblongus, Ag.: v. *Mesodon oblongus*.

Gyrosteus mirabilis, A. S. Woodw.: A. S. Woodward, Naturalist, 1890, p. 101.

Helodus simplex, Ag.: synonym of *Pleuroplax Rankini*.

Holophagus, Eg.: A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 436.

Holoptychius Flemingi, Ag.: includes *Glyptolepis Flemingii*, H. Mitchell, Geologist, 1863, p. 43; J. Powrie, *ibid.*, p. 96.

Ischyodus sp. [n.], A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 290, pl. iii. f. 3. Great Oolite; Northampton. [R. palatine; Jesson Coll.]

Leedsia, A. S. Woodward, Geol. Mag. 1890, p. 292 (substituted for *Leedsichthys*).

———— *problematica*, A. S. Woodward, *ibid.* p. 292, pl. x. f. 9, 10 (olim *Leedsichthys problematicus*).

Lepidotus maximus, Wagner: *Sphærodus neocomiensis* (Ag.), W. Keeping, Foss. Upware, 1883, p. 81, pl. i, f. 4. Neocomian; Cambridgeshire and Bedfordshire.

———— *tuberculatus*, Ag.: = suboperculum of *L. unguiculatus*, Ag. (A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 293).

———— *unguiculatus*, Ag.: A. S. Woodward, *ibid.* p. 292, pl. iii. f. 7, 8. (Includes *L. tuberculatus* and *Pycnodus rudis*).

Leptolepis disjecta [n. sp.], [-us], A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 295, pl. iii, f. 16–19. Stonesfield Slate. [Preop., op., max., and dentary bones; Brit. Mus.]

Macrosemius brevirostris [n. sp.], A. S. Woodward (*ex* Ag.), Proc. Geol. Assoc. vol. xi. (1890), p. 293, pl. iii. f. 9. Stonesfield Slate. [Mandib. ramus; Brit. Mus.]

Megalichthys lævis [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 394. Calcif. Sandst.; Straiton. [Imperfect fishes; Edinb. Mus.]

Mesacanthus, Traq.: genus maintained by Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 481. v. *Acanthodes Mitchelli*.

Mesodon biserialis [n. sp.], A. S. Woodward (*ex* Ag.), Proc. Geol. Assoc. vol. xi. (1890), p. 300, pl. iii. f. 28. Stonesfield Slate. [Mandib. dentition: Brit. Mus.]

———— *Bucklandi* (Ag.): A. S. Woodward, *ibid.* p. 297, pl. iii. f. 20–22: the scales of "*Gyrodus perlatus*" are also figured in the same paper (pl. iii. f. 30, 31). New locality:—Great Oolite of Northampton.

———— *Couloni* (Ag.): *Pycnodus Couloni* (Ag.) W. Keeping, Foss. Upware, 1883, p. 82, pl. i. f. 5. Neocomian; Cambridgeshire and Bedfordshire.

———— *Damoni* [n. sp.], A. S. Woodward, Geol. Mag. 1890, p. 158. This is the *M. sp.*, Woodward and Sherborn, Cat. Brit. Foss. Vert., 1890, p. 121.

———— *Daviesi* [n. sp.], A. S. Woodward, Proc. Zool. Soc. 1890, p. 351, pl. xxviii. f. 5. Purbeck; Swanage. [Fish: Brit. Mus.]

Mesodon ? discoides [n. sp.], A. S. Woodward (*ex* Ag.), Proc. Geol. Assoc. vol. xi. (1890), p. 300, pl. iii. f. 32. Gt. Oolite; Oxford. [Vomer; Brit. Mus.]

——— *latidens*, A. S. W.: misprint for *M. tenuidens*.

——— *oblongus* (Ag.): *Gyronchus (Scaphodus) oblongus*, L. Agassiz, Poiss. Foss. vol. i. (1844), p. xlii. (name only). *Gyronchus oblongus*, E. Wilson, Geol. Mag. 1890, p. 367.

——— *rugulosus* (Ag.): A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 298, pl. iii. f. 23–27. (Includes *M. trigonus*.)

——— sp., Woodward and Sherborn, Cat. Brit. Foss. Vert. 1890, p. 121: v. *M. Damoni*.

——— *tenuidens* [n. sp.], A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 300 (*latidens*, misprint), pl. iii. f. 29. Stonesfield Slate. [R. splenial; Brit. Mus.]

——— *trigonus* (Ag.): synonym of *M. rugulosus*.

Mesolepis rhomba [n. sp.], Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 493. Calcif. Sandst.; Eskdale. [Fish; Edinburgh Mus.]

——— *tuberculata* [n. sp.], Traquair, *ibid.* p. 493. Calcif. Sandst.; Eskdale. [Fish; Edinburgh Mus.]

Mesopoma [n. g.], Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 493 (incompletely defined).

——— *macrocephalum* [n. sp.], Traquair, *ibid.* p. 493.

Rhadinichthys macrocephalus, Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398. Calcif. Sandst.; Pumpherston, Edinburgh. [Fishes; Traquair Coll.]

——— *politum*, Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 493 (olim *Canobius politus*).

——— *pulchellum*, Traquair, *ibid.* p. 493 (olim *Canobius pulchellus*).

Nemacanthus brevis, Phillips: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 289, pl. iii. f. 1.

Nematoptychius gracilis, Traq.: synonym of *N. Greenocki*.

——— *Greenocki*, (Ag.): Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398. (Includes *N. gracilis* and also *Pygopterus elegans*, C. W. Peach, Rep. Brit. Assoc. 1871 (1872), p. 109, name only.)

Oligopleurus vectensis [n. sp.], A. S. Woodward, Proc. Zool. Soc. 1890, p. 346, pl. xxviii, f. 1–4, pl. xxix, f. 1, 2. Purbeck; Swanage. Wealden; I. of Wight. [Head; Brit. Mus.]

Ophiopsis Flesheri (Ag.): A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 293.

Oracanthus Milleri, Ag.: *O. minor*, E. Wilson, Geol. Mag. 1890, p. 368.

Osteolepis microlepidotus, Pand.: Traquair, Geol. Mag. 1888, p. 516, and Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 484.

Oxygnathus, Eg.: A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 431 (includes *Cosmolepis* and *Thrissonotus*).

——— *Egertoni* (Eg.): A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 432 (olim *Cosmolepis Egertoni*).

——— *ornatus*, Eg.: Traquair, Palæoniscidæ (Pal. Soc. 1877), pl. ii. f. 2; A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 432 (includes *Thrissonotus Colei*).

Palæospondylus [n. g.], Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 485.

——— *Gunni* [n. sp.], Traquair, *ibid.* p. 485, woodc. 4. L. Old Red Sandst., Achanarras, Caithness. [The type species, Edinburgh Mus.]

Phaneropleuron, Huxley: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 393.

Phlyctænaspis [n. g.], R. H. Traquair, Geol. Mag. 1890, p. 144. (Olim *Phlyctænius* [preoccupied Zittel, Spongida]).

——— *Anglica*, Traq.: Traquair, *ibid.*, p. 144, (olim *Phlyctænius anglicus*). Includes *Cephalaspis Salweyi*, Lankester (in part), Fishes O.R.S. pt. 1 (Pal. Soc. 1870), pl. viii. f. 2–4.

Phlyctænius, Traq.: preoccupied, v. *Phlyctænaspis*.

Pholidophorus minor, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 293.

Pleuroplax, A. S. Woodw.: J. W. Davis, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 291, pl. xiii.

——— *Rankini*, H. and A.: J. W. Davis, *ibid.* p. 291, pl. xiii. (includes *Helodus simplex*).

Pristacanthus securis, Ag.: A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 290, pl. iii, f. 2.

Psammosteus: The types of *P. granulatus* and *P. vermicularis* are now in the Dublin Mus. Sci. and Art.

Pterichthys Milleri, Ag.: recorded from Achanarras, Caithness, by Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 483. There is also a specimen from this locality in the Worcester Museum.

Ptychodus mammillaris, Ag.: A. S. Woodward, Ann. Rep. Yorks. Phil. Soc. 1889 (1890), p. 39, pl. i. f. 3–14.

———— *polygyrus*, Ag.: A. S. Woodward, *ibid.* p. 40, pl. i. f. 15–20.

Pycnodus Couloni, Ag.: v. *Mesodon Couloni.*

———— *rudis*, Phillips: synonym of *Lepidotus unguiculatus.*

Pygopterus elegans, Peach: v. *Nematoptychius Greenocki.*

Rhadinacanthus, Traq.: genus maintained for *Diplacanthus longispinus*, Ag., by Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 483, but essential part of original definition admitted erroneous and none substituted.

Rhadinichthys carinatus (Ag.): Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 397 (includes typical *R. Geikiei*).

———— *delicatulus*, Traq.: synonym of *R. elegantulus.*

———— *elegantulus*, Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 398, and Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 492 (includes *R. delicatulus* and so-called *R. Geikiei* from Eskdale).

———— *Geikiei*, Traq.: synonym of *R. carinatus* and *R. elegantulus.*

———— *lepturus*, Traq.: synonym of *R. ornatissimus.*

———— *macrocephalus*, Traq. [n. sp.]: v. *Mesopoma macrocephalum.*

———— *ornatissimus* (Ag.): Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 397 (includes *R. lepturus*).

Sagenodus, Owen: This genus must be accepted for the so-called *Ctenodus obliquus* and allied species. It is first defined under the name of *Hemictenodus*, R. H. Traquair, Geol. Mag. 1890, p. 251, and is in part equivalent to *Hemictenodus*, O. Jaekel, Sitzungsb Ges. naturf. Freunde, 1890, p. 7.

———— *caudatus*: correct name of *Ctenodus caudatus.*

———— *corrugatus*: ,, ,, ,, ,, *corrugatus.*

———— *inæqualis*, Owen: the correct name of *Ctenodus obliquus*, with synonyms as already quoted in the Catalogue.

———— *obtusus*: correct name of *Ctenodus obtusus.*

———— *octodorsalis*: correct name of *Ctenodus octodorsalis.*

———— *quinquecostatus*, Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 387. *Hemictenodus quinquecostatus*, Traquair, Geol. Mag. 1890, p. 251 (olim *Ctenodus obliquus*, var. *quinquecostatus*).

Saurichthys acuminatus, Ag.: *S. apicalis*, Portlock, Rep. Geol. Londonderry, 1843, p. 470, pl. xiv. f. 19. Rhætic: N. Ireland.

Sauropsis mordax, Ag.: maxilla of *Aspidorhynchus crassus.*

Scaphodus, Ag. MS.: E. Wilson, Geol. Mag. 1890, p. 367; A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890), p. 300.

———— *heteromorphus* [n. sp.], A. S. Woodward (*ex* Ag.), p. 300, pl. iii. f. 33, 34.

———— *oblongus*, Ag.: v. *Mesodon oblongus.*

Strepsodus minor [n. sp.], R. H. Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 393. Calcif. Sandst.; Pitcorthy. [Scales: Edinb. Mus.]

Strobilodus purbeckensis [n. sp.], A. S. Woodward, Proc. Zool. Soc. 1890, p. 350, pl. xxix. f. 4.

Styracopterus, R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 492 (undefined).

———— *fulcratus*, R. H. Traquair, *ibid.* p. 492 (olim *Holurus fulcratus*, Traq.) Calciferous Sandstones, Tarras Foot (not Glencartholm).

Tarrasius problematicus, Traq.: R. H. Traquair, Ann. Mag. Nat. Hist. [6] vol. vi. 1890, p. 494. Locality is Glencartholm (not Tarras Foot, as originally stated).

Thrissonotus, Ag.: synonym of *Oxygnathus.*

———— *Colei*, Ag.: v. *Oxygnathus ornatus.*

Thynnus scaldisiensis [n. sp.], R. Storms, Mém. Soc. Belge Géol. etc. vol. iii. (1889) p. 163, pl. vii. f. 17–22; A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 294. White Crag: Suffolk. [*Caudal vertebræ*; *Brit. Mus.*]

Thynnus thynnus (Linn.): E. T. Newton, Geol. Mag. 1890, p. 264. Forest Bed: E. Runton. [Vert. centrum; Savin Coll.]

Undina (?) ***barroviensis*** [n. sp.], A. S. Woodward, Ann. Mag. Nat. Hist. [6] vol. v. 1890, p. 436, pl. xvi. f. 5. L. Lias.; Barrow. [Fish: Brit. Mus.]

——— (?) sp. A. S. Woodward, Proc. Geol. Assoc. vol. xi. (1890) p. 292, pl. iii. f. 6 [also figd. by Prevost, Ann. Sci. Nat. vol. iv. 1825, pl. xviii. f. 20]. Stonesfield Slate. [Jugular and pterygo-quad.: Brit. Mus.]

Uronemus, Ag.: Traquair, Proc. Roy. Soc. Edinb. vol. xvii. 1890, p. 393 (includes *Ganopristodus*).

——— ***magnus***, Traq.: = tail of *Ctenodus* or *Sagenodus*, Traquair, Geol. Mag. 1890, p. 252.

——— ***splendens***, Traquair, Geol. Mag. 1890, p. 252 (olim *Ganopristodus splendens*).

AMPHIBIA.

Anthracosaurus Russelli, Huxley: Lydekker, Cat. Foss. Rept. B.M.[1] pt. iv. 1890, p. 158.

Anthracerpetum crassosteum, Ow.: Lydekker, Cat. Rept. pt. iv. 1890, p. 214.

Erpetocephalus, Huxley: synonym of *Ichthyerpetum*.

——— ***rugosus***, Huxl.: v. *Ichthyerpetum Bradleyæ*.

Ichthyerpetum, Huxley: Lydekker, Cat. Rept. pt. iv. 1890, p. 168 (includes *Erpetocephalus*).

——— ***Bradleyæ***, Huxl.: Lydekker, *ibid.* p. 169 (includes *Erpetocephalus rugosus*).

Lepidotosaurus Duffi, Hanc. and Howse: Lydekker, Cat. Rept. pt. iv. 1890, p. 214.

Lepterpetum sp. Lydekker, Cat. Rept. pt. iv. 1890, p. 199. Coal Meas.: Jarrow. [Skeleton: Brit. Mus.]

Loxomma Allmani, Huxley: Embleton, Rep. Brit. Assoc. 1889 (1890), p. 580; Lydekker, Cat. Rept. p. iv. 1890, p. 164, fig. 38.

Macromerium Scoticum [n. sp.], R. Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 291, pl. xii. f. 1, and Cat. Rept. pt. iv. 1890, p. 162. Carb. Limest.; Gilmerton. [Mandib. ramus: Brit. Mus.]

Ophiderpetum Brownriggi, Huxley: Lydekker, Cat. Rept. pt. iv. 1890, p. 206.

Pholidogaster pisciformis, Huxley: Lydekker, Cat. Rept. pt. iv. 1890, p. 195.

Urocordylus reticulatus, Hanc. and Atth.: synonym of *U. Wandesfordi*.

——— ***Wandesfordi***, Huxley: Lydekker, Cat. Rept. pt. iv. 1890, p. 196 (includes *U. reticulatus*).

REPTILIA.

Bothriospondylus suffossus, Owen: Lydekker, Cat. Rept. pt. iv. 1890, p. 242.

Calamospondylus Foxi, Lyd.: Lydekker, Cat. Rept. pt. iv. 1890, p. 243, f. 54.

Camptosaurus Leedsi, Lyd.: Lydekker, Cat. Rept. pt. iv. 1890, p. 258, f. 61.

Cardiodon rugulosus, Owen: Lydekker, Cat. Rept. pt. iv. 1890, p. 236. (*Crown of tooth; Gt. Oolite, Cirencester.*)

Cimoliosaurus portlandicus (Owen): Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 47, f. 5, and Cat. Rept. pt. iv. 1890, p. 274. (Cerv. vert.; Mid. Purbeck, Isle of Portland: Brit. Mus.)

——— ***Richardsoni***, R. Lydekker, Cat. Rept. pt. iv. 1890, p. 276, f. 66.

Cœlosaurus, R. Owen, Cat. Rept. Mus. R. Coll. Surg. 1854, p. 15. [Genus founded on a mutilated centrum of a dorsal vertebra washed out of an oolitic stratum and from the drift of West Norfolk: Mus. R. Coll. Surg.]

Cryptodraco eumerus (Seeley); Lydekker, Cat. Rept. pt. iv. 1890, p. 256.

Goniopholis carinata: first described by R. Owen, Cat. Rept. Mus. R. Coll. Surg. 1854, p. 12, and stated to be from the Great Oolite of Cirencester.

Goniopholis minor, Koken: Lydekker, Cat. Rept. pt. iv. 1890, p. 229. Wealden: Isle of Wight. [*Portions of Skeleton; Brit. Mus.*]

Ichthyosaurus communis, Conyb.: Lydekker, Cat. Rept. pt. iv. 1890, p. 270.

——— ***Conybearei***, Lyd.: Wilson, Geol. Mag. 1890, p. 365.

——— ***intermedius***, Conyb.: Lydekker, Cat. Rept. pt. iv. 1890, p. 271, f. 65.

——— ***thyreospondylus***, Owen: Wilson, *ibid.* p. 365; Lydekker, Cat. Rept. pt. iv. 1890, p. 270 (Portland Oolite, I. of Portland: centrum).

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[1] Subsequent references to this work are briefly entered "Cat. Rept."

Iguanodon Dawsoni, Lyd.: Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 38, f. 1 B, and Cat. Rept. pt. iv. 1890, p. 259.

———— *fittoni*, Lyd.: Lydekker, *ibid.* pp. 38, 43, f. 1 c, and *ibid.* p. 260.

———— *hollingtoniensis*, Lyd.: Lydekker, *ibid.* p. 40, f. 1 E, 2, and *ibid.* p. 262.

———— cervical vertebra of: Lydekker, *ibid.* p. 44, f. 3.

Megalosaurus Dunkeri, Koken: Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 46, f. 4, and Cat. Rept. pt. iv. 1890, p. 244. Wadhurst Clay; Hastings. [Metatarsus; Brit. Mus.]

———— *Oweni*, Lyd.: Lydekker, *ibid.* p. 47, and *ibid.* p. 245.

Metriorhynchus Moreli, Desl.: Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 285, f. 1.

———— *superciliosum* (Blainv.): Lydekker, Cat. Rept. pt. iv. 1890, p. 232.

Ophthalmosaurus icenicus, Seeley: Lydekker, Cat. Rept. pt. iv. 1890, p. 267, f. 62.

———— *Pleydelli* [n. sp.], R. Lydekker, Cat. Rept. pt. iv. 1890, p. 268, f. 63. Kimmeridge Clay: Billingham [Humerus; Dorset Mus.]

Peloneustes, Lyd.: Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 49.

———— *Evansi* (Seeley): Lydekker, *ibid.* p. 52 (olim *Pliosaurus Evansi*).

Pelorosaurus Conybearei (Mant.): Lydekker, Cat. Rept. pt. iv. 1890, p. 240, f. 53.

———— *humerocristatus* (Hulke): Lydekker, *ibid.* p. 241.

———— *Leedsi* (Hulke): Lydekker, *ibid.* p. 242.

———— *Manseli* (Hulke): Lydekker, *ibid.* p. 241.

Plesiosaurus dolichodirus, Conyb.: Lydekker, Cat. Rept. pt. iv. 1890, p. 277.

Pleurocœlus valdensis, Lyd.: Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 182, pl. ix.

Pliosaurus brachydirus, Owen: Lydekker, Cat. Rept. pt. iv. 1890, p. 271. (Teeth; Kimmeridge, I. of Portland. Head of ischium and propodial; Portland Oolite, I. of Portland.)

———— *Evansi*, Seeley: v. *Peloneustes Evansi.*

———— *ferox*, Sauv.: Lydekker, Cat. Rept. pt. iv. 1890, p. 272.

Rhamphorhynchus jessoni [n. sp.], R. Lydekker, Cat. Rept. pt. iv. 1890, p. 226, and Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 431, f. 1–4. Oxford Clay; St. Ives. [Bones; Brit. Mus.]

Steneosaurus brevidens (Phill.): Lydekker, Cat. Rept. pt. iv. 1890, p. 234. New locality is Great Oolite; Northampton.

———— *Boutilieri*, Desl.: v. *S. robustus.*

———— *robustus*, R. Owen, Cat. Foss. Rept. Mus. R. Coll. Surgeons, 1854, p. 11. M. Oolite; Oxfordshire. [Skull and mandible; ? Oxford Mus.] [Includes *S. oxoniensis* and *S. boutilieri*, according to G. A. Boulenger, *in litt.*]

Streptospondylus Meyeri, R. Owen, Cat. Rept. Mus. R. Coll. Surgeons, 1854, p. 16. Wealden; Brook. [Dorsal vertebræ, probably of *Iguanodon bernissartensis*; Mus. R. Coll. Surgeons.]

Suchodus [n. g.], Lydekker, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 288.

———— *durobrivensis* [n. sp.], Lydekker, *ibid.* p. 288, f. 2, 3. Oxford Clay; Peterborough. [Mandib. symphysis; Leeds Coll.] The type species.

Syngonosaurus macrocercus, Seeley: Lydekker, Cat. Rept. pt. iv. 1890, p. 254, f. 60. [Vertebræ; Cambridge Greensand.]

Teleosaurus brevirostris, R. Owen, was first described in Cat. Rept. Mus. R. Coll. Surgeons, 1854, p. 8, as from "Oolite; Chipping Norton." [Skull and mandible; ? Oxford Mus.]

Thecodontosaurus platyodon (Riley and Stutch.): Lydekker, Cat. Rept. pt. iv. 1890, p. 246. (Two crowns of teeth; ? Keuper, Somersetshire.)

[Genus non det.] Axis vertebra and intercentrum of Dinosaur: Lydekker, Cat. Rept. pt. iv. 1890, p. 245, f. 55. (See Woodward and Sherborn, Cat. Brit. Foss. Vert. 1890, p. 296.)

"Horn-like Dinosaurian Bone," R. Lydekker, Quart. Journ. Geol. Soc. vol. xlv. (1890) p. 185. fig. [? Ungual phalanx.]

"Ichnites," T. P. Barkas, Rep. Brit. Assoc. 1889 (1890), p. 565. (Carbonif. Sandst.; Northumberland.)

———— Lydekker, Cat. Rept. pt. iv. 1890, p. 215.

Aves.

Fulica atra, Linn.: A. Milne-Edwards, Oiseaux Foss. vol. ii. 1871, p. 160. Fens; Cambridge.

Haliaetus pelagicus (Pall.): The type is a *tibia*, not *humerus*.
Phalacrocorax carbo (Linn.): A coracoid in Brit. Mus. has been referred to as = *Graculus carbo*? by A. Milne-Edwards, Oiseaux Foss. vol. i. 1868, p. 277, vol. ii. 1871, p. 592.
Lithornis vulturinus, Owen: The type is in Mus. Coll. Surgeons, not in Brit. Mus.
Tetrao urogallus, Linn.: A. Newton and H. Saunders, in Yarrell, Hist. Brit. Birds, ed. 4, 1882–4, vol. iii. p. 47. [Bones; Cave, Teesdale.]

MAMMALIA.

Ailurus anglicus, Dawk.: Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 451, pl. xviii. f. 9. [Molar from nodule-bed (Red Crag), Boyton; Mus. Pract. Geol.]
Alces latifrons (John.): The type of *Cervus booides* is a portion of skull, with beam; Norwich Mus.
———— ***machlis***, Ag.: The type of *A. palmatus*, Ow., is metacarpus, antibrachium and humerus, Brit. Mus.
Bos taurus, var. ***longifrons***, Owen: The type of *B. longifrons* is a frontlet and horn-core; Mus. R. Coll. Surgeons. This was first named *Bos brachyceros* by Owen, and subsequently *Bos latifrons* by Wilde. It is also the "Small ox" of Wood; see Woodward and Sherborn, Cat. Brit. Foss. Vert. 1890, p. 322. The type of *Bison minor* is a metatarsal; ? Mus. R. Coll. Surgeons.
———— var. ***primigenius*** (Boj.): recorded from Crofthead by J. Geikie, GEOL. MAG. 1868, p. 393. The type of *Bos giganteus*, Davies, is a cranium; Brit. Mus.
Capra ibex, Linn.: A. Newton, Zool. Ancient Europe, 1862, p. 13, footnote. Pleist.; Fulbourne, Cambridge. [? Horns; Camb. Mus.]
Cervus elaphus, Linn.: The type of *Strongyloceros spelæus*, Ow., is a base of antler, Brit. Mus.
———— ***giganteus*** (Blum.): The type of *Megaceros hibernicus* is skeleton; Mus. R. Coll. Surgeons. This is also the type of the genus *Megaceros*. In the addenda to Woodward and Sherborn's Catalogue, p. 396, "page 333," the word "tooth" should read "portion of antler."
Dacrytheruim ovinum (Owen): v. *Xiphodon platyceps*.
Didelphys Colchesteri, Owen: There are some notes on these teeth in E. Charlesworth, Mag. Nat. Hist. n. s. vol. iv. app. pp. 44–72.
Felis brevirostris, Croiz. and Job.: Laing, Rep. Brit. Assoc. 1889 (1890), p. 582. Creswell Caves.
Hippopotamus amphibius, Linn.: The type of *H. major*, Ow., was a lower jaw, *olim* Miss Anna Gurney Coll.
Hyracotherium leporinum, Owen: W. H. Flower was the first to identify *Pliolophus vulpiceps*, Ow., with this species. See Cat. Mus. Vert. R. Coll. Surgeons, 1884, p. 380, and Ency. Brit. vol. xv. 1884, p. 428. [R.L.]
Leucippe Oweni, A. Pomel, Cat. Méth. Vert. Foss. 1853, p. 10. A name used for genus and species of English fossil bat: Pomel refers to Geol. Journ. London, without page or other reference.
Lutra dubia (Blainv.): E. T. Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 444, pl. xviii. f. 1. Red Crag: Woodbridge. [R. mandib. ramus; E. C. Moor Coll.]
———— ***Reevei*** [n. sp.], E. T. Newton, *ibid.* p. 446, pl. xviii. f. 2. Norwich Crag; Bramerton. [Lower sectorial molar; Reeve Coll.]
Machærodus crenatidens [n.sp.] E. Fabrini, Boll. Com. Geol. Ital. vol. xxi. 1890, p. 162. (Refers Backhouse and Lydekker, Quart. Journ. Geol. Soc. vol. xlii. 1886, p. 309, pl. x. to this form.)
Mesoplodon Floris [n. sp.], E. T. Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 448, pl. xviii. f. 7 A-C (olim *M. Floweri*, Flower (*ex* Canham MS.) *non* v. Haast).
———— ***Floweri***, Fl.: v. *M. Floris*.
———— ***scaphoides*** [n. sp.], E. T. Newton, *ibid.* p. 450, pl. xviii. f. 8. Red Crag; Woodbridge. [Rostrum; Mus. Pract. Geol.]
Microtus amphibius (Linn.): Newton, GEOL. MAG. 1890, p. 453. [Records mandib. fragment from Ilford in Mus. Pract. Geol. and says others are known from Crayford and Erith.—Pleistocene.]

Microtus ratticeps (Keys. and Blas.): Newton, *ibid.* p. 453, f. 1, 2. [Records remains from Crayford and Erith in Mus. Pract. Geol. and F. C. J. Spurrell Coll.]

Myodes lemmus (Linn.): Newton, Geol. Mag. 1890, p. 455, f. 7, 8. [Recorded from Erith Pleistocene: mandib. ramus and teeth, F. C. J. Spurrell Coll.]

——— *torquatus* (Desm.): Newton, *ibid.* p. 454, f. 3–6. [Recorded from Erith Pleistocene: r. mandib. ramus, F. C. J. Spurrell Coll.]

Neurogymnurus, Filhol. Prof. Rosenberg, of Dorpat, points out that this name, though invariably adopted, is a misprint for *Necrogymnurus*.

Phoca Moori [n. sp.], E. T. Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 446, pl. xviii. f. 3. Red Crag: Woodbridge. [L. humerus; E. C. Moor Coll.]

Phocanella minor, P. J. van Beneden: E. T. Newton, Quart. Journ. Geol. Soc. vol xlvi. 1890, p. 447, pl. xviii. f. 4. Red Crag: Woodbridge. [Humerus; E. C. Moor Coll.]

Platychœrops Richardsoni, Charlesw.: [R. Lydekker] Ann. Rep. Yorks. Phil. Soc. 1889 (1890), p. 35, pl. 1, f. 1.

Trogontherium minus [n. sp.], E. T. Newton, Quart. Journ. Geol. Soc. vol. xlvi. 1890, p. 447, pl. xviii. f. 5 (? 6). ? Includes incisor from Sizewell Gap, Norwich Crag, in Geol. Soc. Mus. (Owen, Brit. Foss. Mamm. 1846, p. 192). Red Crag; Woodbridge. [R. maxilla; E. C. Moor Coll.] ? Norwich Crag; Suffolk.

Xiphodon platyceps, Flower: "May be *Dacrytherium ovinum*," R. Lydekker, Cat. Foss. Mamm. B.M. pt. ii. 1885, p. 187.

N.B.—General information on the distribution of Pliocene and Pleistocene Fossil Vertebrata will also be found in the following works:—

W. Whitaker, "The Geology of London and of Part of the Thames Valley," 2 vols. 8vo., London (Geol. Survey), 1889.

C. Reid, "The Pliocene Deposits of Britain," 8vo., London (Geol. Survey), 1890.

W. and S.

NOTICES OF MEMOIRS.

I.—Prof. Capellini on a Fossil Italian Species of *Tomistoma*.

G. Capellini. Sul Coccodrelliano Garialoide (Tomistoma calaritanus), scoperto nella Collina di Cagliari nel 1868. Mem. Ac. Linc. (4) Vol. VI. 1890, 4 Plates.

Till within the last few years the existing Schlegel's Gharial, of Borneo, was the only known representative of the genus *Tomistoma*, the skull of which is readily distinguished from that of the Gangetic Gharial (*Garialis gangeticus*) by the forward extension of the nasals to join the premaxillæ in the long snout. Within that period fossil remains of this genus have, however, been determined from the Miocene of Malta (*T. champsoides*) and Lower Austria (*T. eggenburgense*), while it has been suggested that Blainville's *Crocodilus macrorhynchus*, from the Cretaceous Pisolite of France, might also be included in the same genus. In the memoir before us the learned Professor of the University of Bologna makes us acquainted with a third species from Italian strata, for which he proposes the name *T. calaritanus*.[1] This species is described upon the evidence of a skull, somewhat imperfect posteriorly, which was obtained in 1868 from beds at

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[1] *T. calaritanum* would appear to be more correct.

Cagliari, which are probably of Miocene age. Prof. Capellini first gives us a plate illustrating the specimen in the condition in which it was obtained from the quarry, and then a larger plate showing the skull completely extracted from its matrix. All the characteristic features of the genus *Tomistoma* are displayed in these plates, so that there is no doubt as to the correctness of the generic determination. The general characters are also very similar to those of the Austrian *T. eggenburgense* (which the author considers is rightly included in *Tomistoma*, although originally described as *Gavialosuchus*); but the snout is relatively shorter and thicker, and the supratemporal fossæ are more nearly circular.

The gradually accumulating evidence of the abundance of *Tomistoma* during the Tertiary period in Europe shows conclusively that the solitary existing species of the genus is one of the many instances of the survival in the Oriental region of ancient European types.

We may mention in passing that the author adopts the amended name *Garialis* in place of the ordinary and incorrect *Gavialis*.

R. L.

II.—Dr. Otto Jakel on Perforating Fungi in Fossil Elasmobranch Teeth.

"Gänge von Fadenpilzen (*Mycelites ossifragus*, Roux) in Dentinbildungen." By Otto Jaekel. [Sitzungsb. Ges. naturf. Freunde, 1890, pp. 92-94.]

During the microscopical examination of sections of the fossil rostral teeth of *Pristiophorus*, Dr. Jaekel observed the minute branching tubes of a boring organism. The latter he regards as a fungus already described by W. Roux as infesting bones and teeth. Similar borings are recorded in "*Sphenodus ornati*," *Corax heterodon*, *Acanthias orpiensis*, *Notidanus primigenius*, and a new extinct species of *Trygon*. We would add that similar borings have already been noticed in fish-scales from the English Chalk.

III.—Dr. W. Dames on a Nothosaurian Reptile from the Muschelkalk.

"*Anarosaurus pumilio*, nov. gen., nov. sp." By Prof. W. Dames. [Zeitschr. deutsch. geol. Ges. 1890, pp. 74–85, pl. i.]

The author describes the remains of the head, neck, and abdominal region of a small Nothosaurian, from the Lower or Middle Muschelkalk of Remkersleben, west of Magdeburg. The specimen is preserved in the Royal University Museum, Göttingen, and it is well shown with its counterpart, of the natural size, in the plate accompanying the memoir. At first sight the reptile appears to be a miniature *Nothosaurus*, but it is considered to be generically distinguished by the club-shaped form of its lower side-teeth, and by the total absence of a cleft in the glenoid border of its coracoid. *Anarosaurus* (as the new genus is termed) is also distinguished from *Lariosaurus* by its dentition, and differs from the type species of the latter in the slenderness of its ribs and femur, and in the relatively greater length of the neck. *Pachypleura* (or *Neusticosaurus*) has no front teeth such as characterize the form now described, and there are differences in the limbs. *Dactylosaurus* is also excluded from comparison both by its short, stout, cervical vertebræ, and by the absence of an epicondylar foramen in the humerus. Dr. Dames' study of the subject leads him to conclude, that all the Triassic *Nothosaurus*-like reptiles may well be comprised within a single family, that of Nothosauridæ; while the remarkable Mesosauridæ ought not to be regarded as very closely related.

A. S. W.

IV.—On the Mexican Meteorites, with especial regard to the supposed occurrence of wide-spread Meteoritic Showers. By L. Fletcher, M.A., F.R.S., with maps of the region. Mineralogical Magazine, Vol. IX. No. 42, pp. 91–180.

In this most important contribution to Meteoritic Literature, Mr, Fletcher first points out that the "prevalent belief in wide-spread meteoritic showers" is "as regards the desert of Atacama, based on insufficient evidence," and then goes on to make observations, from which it would appear that he includes Mexico in this statement. Mr. Fletcher notes the Meteoritic falls actually observed (only seven in number); the localities in which Meteoritic masses have been found; the distribution in each locality; the transportation of masses; the natural or artificial dispersion of masses belonging to a single type; and the facts which seem to him to prove that many of the masses probably belong to a single fall. Numerous other points are also carefully considered and the history of each known mass is treated in detail, the actual locality being shown on the maps appended. Although dealing with the Meteoritic falls in a limited district, this paper throws a great light on the general subject and will be found most instructive to all those who are interested in cosmical phenomena.

REVIEWS.

I.—Dr. Ristori on Fossil Italian Apes.

Ristori, G. Le Scimmie Fossili Italiane. Boll. Com. Geol. Vol. VII. Nos. 5–8 (1890).

In this communication the author affords us some important and interesting information as to the affinities of the fossil Ape from the Miocene of Monte Bamboli known as *Oreopithecus bambolii.* This Ape was originally described by Gervais on the evidence of an imperfect lower jaw of an immature individual; and was then regarded as being a true anthropoid. Quite recently, however, Dr. Max Schlosser came to the conclusion that the genus has nothing to do with that group, but was very closely allied to *Cynocephalus.*

Dr. Ristori now describes and figures a number of imperfect jaws, and considers that while there are undoubtedly some signs of affinity with the *Cercopithecidæ,* as represented by *Semnopithecus* and

Cynocephalus, yet there are others of fully equal importance connecting it with the *Simiidæ*, the characters being, indeed, so equally balanced that the author appears to be undecided to which family it should be referred. Among the characters allying *Oreopithecus* to the inferior apes are the great length of the dental series, and the elongation of the last molars—especially those of the lower jaw. On the other hand, anthropoid affinities are displayed in the shortness of the face, the rounding of the chin, and the contour of the molars, in which the tubercles are arranged diagonally, and do not exhibit the complete cross-crests of the *Simiidæ*. The species was of somewhat larger size than a Gibbon; and it appears highly probably that the author is right in considering this interesting form as one of the ancestors of the existing anthropoid Apes.

The remainder of the paper is devoted to the consideration of *Semnopithecus monspessulanus* and *Macacus* (*Inuus*) *florentinus* of the Pliocene of the Val d'Arno. The latter was originally described by Cocchi as the type of a distinct genus, under the name of *Aulaxinuus*; and it appears that Dr. Forsyth Major's *Macacus ausonianus* is merely a synonym of this form.

We are much interested to learn that this memoir is one of a series intended to illustrate the whole of the Mammalian fauna of the Italian Tertiaries, if the necessary funds are supplied by the Government. The importance of such a series cannot be overestimated, not only to the students of Italian palæontology, but likewise to those of other countries—and more especially England. We therefore most earnestly hope that the Italian Government will be induced to afford the supplies necessary to continue this most important work, which we feel sure will be well carried out under the direction of Professor Stoppani. R. L.

II.—Dr. K. A. von Zittel's Handbook of Palæontology.

Handbuch der Palæontologie—Palæozoologie, Band III. Lief. 4. By Karl A. von Zittel. pp. 633–900, woodcut figs. 561–719. (R. Oldenbourg, Munich and Leipzig, 1890.)

THE fourth part of the third volume of this work, relating to Palæozoology, has just been issued, and extends to the end of the section Aves. The index and title-page of vol. iii. are also added, and there is a short list of Corrigenda, chiefly in connexion with the class Pisces. The Order Crocodilia occupies the first fifty pages, and is regarded as comprising the three suborders of Parasuchia, Pseudosuchia, and Eusuchia; the second being founded for the reception of the remarkable Triassic genera *Aetosaurus*, *Typothorax*, and *Dyoplax*, while the third includes both the Eusuchia and Mesosuchia of Huxley's classification. Few of the illustrations are new, but the selection of published figures is such as to render Dr. von Zittel's account the most completely illustrated synopsis of the order that has hitherto appeared. The number of genera with appended queries shows how much scope for investigation still remains for any one able to undertake an extended review of available materials; and there will doubtless be much difference of opinion upon some of the author's views of synonymy. The difficult task of presenting an impartial and comprehensible *résumé* of the Dinosauria (as they are still termed) is accomplished in Dr. von Zittel's best style. Several pages are devoted to the history of the classification of the order, with an outline of its principal osteological characters; and considerable space is then occupied with a detailed account of each of the principal types. Three subordinal divisions—Sauropoda, Theropoda, and Orthopoda—are adopted, and of the numerous illustrations no less than two-thirds are the fine woodcuts published in the well-known memoirs of Prof. Marsh. In contributions to knowledge of this order, indeed, Europe sinks into insignificance, except as regards the Iguanodontidæ, Compsognathidæ, and Zanclodontidæ. As in the case of the Crocodilia, some of the nomenclature adopted will not meet with general approval, especially in the New World; but Dr. von Zittel has wisely selected for special prominence a series of the most satisfactorily preserved types, recording them under the names they received in the original memoirs, thus enabling the student and general reader to obtain a clear idea of the subject without becoming involved in the perplexities of synonymy, which none but a specialist, with the actual materials before him, can understand. The Pterosauria constitute the last order of Reptiles discussed, and are illustrated by several fine figures of remains from the Bavarian Lithographic Stone. The author's well-known memoir of 1882 forms the basis of much that has scarcely been incorporated in a text-book previously; and the introduction of the graphic restored figure of *Rhamphorhynchus*, originally adorning that memoir, is a new feature in the present "Handbuch."

The preliminary chapter to the class Aves is of the usual concise and complete character; and in the systematic description the three orders of Saururæ, Ratitæ, and Carinatæ are recognized. Owen's original figure of *Archæopteryx* is not dispensed with, as often happens now, to make way for an illustration of the beautiful fossil in Berlin; but both are given, the one made to supplement the other. Hochstetter's restored portrait of *Dinornis* is as effective as the sketch of *Rhamphorhynchus* already mentioned, and forms a well-chosen contrast to the dry bones on the succeeding pages. The genera *Meionornis* and *Palapteryx* are admitted as distinct from *Dinornis*, but the so-called *Euryapteryx* becomes a synonym of the second, as determined by Hutton and Fürbringer. The Odontolcæ are referred to the Ratitæ, and the Odontormæ to the Carinatæ; and the numerous recent families of Carinatæ with extinct representatives are arranged in sixteen suborders, the latest researches of Fürbringer being especially taken into consideration. Most of the genera are simply recorded, but a brief statement of characters or distribution is given in the case of some of the principal types; and the only important omission in the references to literature we notice is Symington Grieve's work on the Great Auk.

The index to the volume, comprising both genera and species, occupies thirty-four pages of three columns each, and both students and investigators in the Palæontology of the Lower Vertebrates will feel that at last they have some definite and satisfactory basis to work upon. Dr. von Zittel is to be congratulated upon the completion of another part of his laborious undertaking, and the most gratifying reward that the Professor can receive must be the very evident improvement in the respective authors' knowledge of the literature of the subject in recent contributions to the Palæontology of Fishes, Amphibians, and Reptiles. A. S. W.

III.—DR. OTTO JAEKEL ON THE SYSTEMATIC POSITION AND FOSSIL REMAINS OF *Pristiophorus*.

"UEBER DIE SYSTEMATISCHE STELLUNG UND UEBER FOSSILE RESTE DER GATTUNG *Pristiophorus*." By OTTO JAEKEL. [Zeitschr. deutsch. geol. Ges. 1890, pp. 86–120, pls. ii.–v.]

THIS is a valuable contribution to our knowledge of an interesting Selachian family, of which few traces have been met with among fossils. Six-sevenths of the memoir relate to the skeleton of the existing species, comprising observations made in the Berlin and British Museums; and the remaining pages are devoted to a description of the fossil remains regarded by the author as pertaining to the same type. Prof. Carl Hasse has already recorded vertebræ of *Pristiophorus* from the Molasse of Baltringen, Würtemberg; and Dr. Jaekel now describes rostral teeth from the same formation and locality, considered to justify the establishment of a new species, *Pristiophorus suevicus*. The fossils from the Amuri Beds of New Zealand, determined by J. W. Davis to be caudal spines of a new species of *Trygon* (*T. ensifer*), are now shown, from microscopical characters, to be rostral teeth of another extinct form of *Pristiophorus*. The remarkable *Sclerorhynchus*, from the Upper Cretaceous of Mount Lebanon is also discussed and considered to be a subgenus of *Pristiophorus*. As, however, a discovery in the British Museum a year ago (Proc. Zool. Soc. 1889, p. 450) suggested, and probably proved, that the trunk of the Lebanon genus had been erroneously described under the name of *Squatina crassidens*, it may be well that Dr. Jaekel should reconsider the subject. There is a fine example of the so-called *S. crassidens* in the Noetling Collection at Berlin, which will probably be available for study and comparison.

A. S. W.

IV.—PROCEEDINGS OF THE GEOLOGISTS' ASSOCIATION, Vol. XI. No. 8. November, 1890.

AMONG the many papers in this number, that of Mr. B. B. Woodward, on the Pleistocene (non-marine) Mollusca of the London Basin seems to be the most valuable. It is this kind of contribution that we like to see, this collecting together, and adding to, of all available information on one subject. Indeed in these days of unlimited writing, the author who takes the trouble to sift the wheat from the chaff deserves as much, or even more thanks, than he who adds scrappy notes to the mass. Mr. Woodward has presented to us, in some fifty pages, the results of all researches in the subject, and further he has crammed his paper with observations and notes of such value, that it must constitute the principal source of reference to future workers. The paper is well illustrated and it is highly creditable to the Association that they have devoted so much space to this, and so assisted the reader and rendered the work of greater service. A list of the Pleistocene (non-marine) Mollusca is appended, with the correct nomenclature, but such great confusion still exists in the question of priority, that no doubt two of the genera will be changed in the addenda to the completed volume.

A full report of the Excursion of the Association to the Italian Volcanoes, by Dr. Johnston Lavis follows, and should be of material service to those who could not avail themselves of Dr. Lavis' personal guidance, on that interesting occasion.

Professor Boulger contributes a paper on *Capulus*, containing the description of a new species, illustrated by a coloured plate. Other papers of great interest by Dr. Wheelton Hind, Major-Gen. McMahon, T. P. Moody, H. W. Monckton, G. F. Monckton (Gold Deposits of Nova Scotia), H. M. Klaassen, and W. J. Lewis Abbott, complete this bulky number, but space does not permit us to notice all these contributions in detail.

V.—RECORDS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES. Vol. II. Part 1, pp. 1–36, with 3 tables, 2 plates and a map. (Sydney, Department of Mines, 1890.)

I. Mr. T. W. EDGEWORTH DAVID publishes a proposed "Petrological Classification for the Rocks of New South Wales," giving the terms, lettering and signs to be employed by the Survey.

II. Under the name *T. Lonsdalei.* Mr. R. ETHERIDGE, jun., describes a new species of *Tryplasma*, Lonsdale (*Pholidophyllum*, Lindström), from the Upper Silurian of N.S. Wales. The "pores" described by Lonsdale, the existence of which was doubted by Lindström, are explained as impressions of the thorn-like septa in the matrix filling the inter-tabular spaces. In the same paper Mr. Etheridge assigns doubtfully to *Diphyphyllum* a new species, *D. Porteri*, from the Devonian limestones near Tamworth, N.S.W. The specimens show interesting structural features, and suggest the existence of an inner wall.

III. Mr. W. ANDERSON has some notes of considerable practical value "on the Tertiary Deep Lead at Tumbarumba," an auriferous river-bed covered by lava-flows. The paper is accompanied by a map.

IV. In a paper of anthropological rather than of geological interest Mr. R. ETHERIDGE, jun., describes and figures "The Aboriginal Rock-Carvings at the Head of Bantry Bay, Middle Harbour, Port Jackson," which he thinks "formed a portion of a *Bora*-ground, the spot set apart for the performance of the initiatory mysteries attending the entrance of youths into manhood's estate."

V. is a note on *Dromornis Australis*, Owen, by the same writer.

Possibly the low price of this publication—1*s.* 6*d.*—is held to excuse the misprints that disfigure it: the Government printer should have his attention drawn to these, especially in Article II.

REPORTS AND PROCEEDINGS.

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GEOLOGICAL SOCIETY OF LONDON.

I.—Nov. 12, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.

The PRESIDENT reported that Mr. L. Belinfante had been temporarily appointed by the Council to the Office of Assistant-Secretary.

The following communications were read:

1. "On the Porphyritic Rocks of the Island of Jersey." By Prof. A. De Lapparent, Foreign Correspondent of the Society. (Communicated by the President.)

The author had some years ago described as Permian a series of porphyritic rocks, of which specimens had been sent to him from Jersey. He had since been led to believe that this view of their age, arrived at from what he knew of similar rocks in France, was erroneous, and in a recent visit to the island had satisfied himself that the English observers who had assigned to these rocks a much higher antiquity were in the right. He now found that the igneous rocks in question underlie the Rozel conglomerate, which must be placed at the very base of the Silurian formations. He reserved his detailed statement for a communication to the Geological Society of France; his present object being to do justice to English geologists, whose views he had formerly opposed.

2. "On a New Species of *Trionyx* from the Miocene of Malta, and a Chelonian Scapula from the London Clay." By R. Lydekker, Esq., B.A., F.G.S.

(i.) The anterior portion of a carapace from the Miocene of Malta exhibits a divided neural between the first pair of costals, as in the Indian species of *Trionyx*, and in *Chitra*. The author describes this Maltese fossil, and discusses its relationship to *Trionyx* and *Chitra*, and names it *Trionyx melitensis*.

He notes the interest of finding another Oriental form in the Miocene of the Maltese Islands, which has already yielded a species of *Tomistoma*.

(ii.) A large scapula from the London Clay of Sheppey is referred to *Eosphargis gigas*, and is considered to support Dr. Baur's view as to the intimate affinity between the *Dermochelyidæ* and *Chelonidæ*.

3. "Notes on Specimens collected by W. Gowland, Esq., F.C.S., in the Korea." By Thomas H. Holland, Esq., of the Geological Survey of India, late Berkeley Fellow of the Owens College. (Communicated by Prof. J. W. Judd, F.R.S., F.G.S.)

The southern half of Korea traversed by Mr. Gowland is of a hilly character. The rocks forming the hills are chiefly crystalline schists—gneisses with graphite, garnet, dichroite, and fluor occurring in considerable abundance, and the whole group is probably part of the great Archæan mass of North-east China. The author describes these metamorphic rocks in detail.

Stratified rocks, probably of Carboniferous age, lie unconformably upon the schists in the south-eastern part of the peninsula, and petrographical notes of these are given in the paper. Through the crystalline schists and stratified rocks various igneous rocks have been erupted as dykes or in large masses. Amongst these the most conspicuous rock is granite. Biotite- and muscovite-granite are most widely distributed, and in places are cut by dykes of eurite and veins of quartz and pegmatite. The more basic class of rocks is represented by diorites, propylites, andesites, basalts, dolerites, and gabbros. Interesting cases of the gradual passage between the so-called intermediate and basic rocks are found, and various stages in the devitrification and decomposition of andesitic lavas represented. These are described in detail by the author, and compared with similar cases in other regions; and full descriptions of the intrusive rocks are furnished.

There are now no active volcanoes; and there is a notable lack of mineral wealth in the southern part of the Korea.

4. "Further Notes on the Statigraphy of the Bagshot Beds of the London Basin (north side)." By the Rev. A. Irving, D.Sc., F.G.S,

1. The author brings forward new evidence from well-sections, clay-pits recently opened, and excavations, confirming the reading of the country between Wellington-College and Wokingham Stations on the S.E. Railway, as put forward by him in 1887 (Q. J. G. S. vol. xliii. and figure 1 of the paper). We have now actual data for the gradients of the clay-beds, and the thinning-out of both the Lower (fluviatile) Sands and of the Middle green-earth series; the latter, when taken into account, bringing the clays in the Wokingham outlier into stratigraphical alignment with the basal clays of the Middle Group. Certain clays at California are also shown to be in alignment with these; and a sketch-section from Ambarrow to Barkham Hill shows the relative gradients of certain horizons to be such as to justify the relegation of the Pebble-bed there to the base of the Upper Sands; while a microscopical examination of the sands above it brings out the lithological identity of these and of the sands capping Farley Hill with the basal beds of the Upper Sands at Wellington College and on Finchampstead Ridges. The accidental occurrence of thin seams of pipe-clay is rejected as a test of horizons, as affording only ambiguous evidence.

2. A similar succession is shown in a section drawn from Wellington College Well through the sand-pit at the brick-yards by Ninemile Ride (base of the Middle Clays exposed), Easthampstead Church Hill (with more recent data), and Bill Hill (Easthampstead), to the S.W. Railway at Bracknell, bringing the higher beds of those two hills into the horizon of the Upper Sands. Further notes are also added to those of the author's 1888 paper (Q.J.G.S. vol. xliv.) on the Ascot Hills, Englefield Green, and Windsor Park, where the transgressive relation of the Bagshot Beds to the London Clay is maintained.

3. In conclusion, the author points out that the new well-sections confirm the trustworthiness of that at Wellington College as a vertical datum-line; he criticises the views of previous writers and maintains that, with the aid of Lieut. Lyons' recently published contour-map, we can now discriminate between the effects of con-

temporaneous and post-Eocene earth-movements in the area; and that the physical history of the Bagshot Beds, which he has himself propounded, is substantiated by the stratigraphical evidence.

II.—Nov. 26, 1890.—A. Geikie, F.R.S., President, in the Chair. —The following communications were read:—

1. "Account of an Experimental Investigation of the Law that Limits the action of Flowing Streams." By R. D. Oldham, Esq., A.R.S.M., F.G.S., Deputy Superintendent of the Geological Survey of India.

The author brings forward evidence derived from experiments in support of the views expressed in a paper submitted to the Society in 1888. His apparatus consisted of a sloping trough, through which various amounts of water containing definite percentages of sand could be sent. The lower end of the trough issued on to a semicircular platform.

In three experiments with the trough at a slope of 1 in 20, and with the same work to be done in each case, the resulting slopes after sand had accumulated in the trough were as follows:—With one part of sand to 42 of water, a slope of 1 in 40; with 1 of sand to 28 of water, 1 in 20; and with 1 of sand to 14 of water, 1 in 13·3. These slopes were obtained when a condition of equilibrium had been maintained so that the water was just able to transport its burden. By increasing the supply of water from 14:1 to 42:1, the original slope was eventually obtained.

On the fan formed on the horizontal platform variations in the water supply did not produce nearly so marked an effect as in the confined channel, and the slope varied considerably in different directions.

After a time a channel was cut back into the fan, and its sand swept forward and deposited as a secondary fan in front of the first; and as this grew, it cut back into the reach above, and this in turn cut back towards the head of the fans, and sometimes into the trough. In some cases other secondary fans were formed on the margin of the main fan, but the apparatus was not large enough for further formations. The general slope of the fans, both primary and secondary, was ·06, and that of the reach only ·04, while at the head of the reach, where it was cutting back into the face above, there was a gradient of ·08

The general tendency of the experiments supports not only the specific conclusions as to the normal form and behaviour of a river which has attained a state of equilibrium, but to a greater degree the fundamental assumption that a river will adapt its channel to such a slope and form as will enable it to just transport a solid burden cast upon it.

2. "On the Rocks of North Devon." By Henry Hicks, M.D., F.R.S., Sec.G.S.

During a recent visit to North Devon the author obtained evidence which has led him to believe that far too little importance has hitherto been assigned to the results of movements in the Earth's crust as affecting the succession of the rocks in that area. The supposed continuous upward succession from the rocks on the shore of the Bristol Channel to those in the neighbourhood of Barnstaple, including, according to some authors, no less than ten groups, and classed into three divisions under the names Lower, Middle, and Upper Devonian, is, the author believes, an erroneous interpretation. The beds, he says, have been greatly plicated and faulted, and consequently several times repeated, and instead of being one continuous series, they occur folded in more or less broken troughs. In the Morte Slates, previously considered unfossiliferous, the author found a *Lingula*, and he believes that these slates are the oldest rocks in the area, and formed the floor upon which the Devonian Rocks were deposited unconformably. As the result of movements in the Earth's crust, the Morte Slates have been brought to the surface and thrust over much newer rocks, producing a deceptive appearance of overlying the latter conformably. The Morte Slates mark the dividing line between the two main troughs. On the north side in ascending order are the Hangman (or Lynton), Combe Martin Bay, and Ilfracombe Beds, and on the south side the Pickwell Down, Baggy Point, and Pilton Beds. Those on the south side of the Morte Slates are, the author believes, a repetition of the beds on the north side. The palæontological evidence is not antagonistic to this view, for an analysis of the Brachiopoda, the only group of fossils in the beds on the south side, which hitherto have been systematically examined, shows that of the twenty species mentioned by Mr. Davidson and others as occurring in the Pickwell Down, Baggy Point, and Pilton Beds (the so-called Upper Devonian rocks), no less than thirteen have already been found in the Middle or Lower Devonian rocks on the north side of the Morte Slates. Four others are recognized Middle Devonian species in other areas; and the three remaining are either doubtful species or ones which have a great vertical range. These facts show that the so-called Upper Devonian rocks in this area do not contain a distinguishing fauna of any importance; and the stratigraphical evidence is opposed to the view that they are a series of rocks distinct from those on the north side of the Morte Slates, which have been classed as Middle and Lower Devonian.

III.—December 10, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "On some Water-worn and Pebble-worn Stones taken from the Apron of the Severn Commissioners' Weir erected across the River at Holt Fleet about eight miles above Worcester." By Henry John Marten, Esq., M.Inst.C.E., F.G.S., etc., Engineer to the Severn Commissioners.

The Weir referred to in the paper was built in 1844 of soft red sandstone, and some of the stones composing the apron of the Weir showing signs of decay were removed in 1887. The average quantity of water passing over each square foot of the stones composing the apron has been estimated at about 2000 gallons per minute. A large proportion of the stones had been drilled through and through by the action of the current upon small pebbles lodged in hollows or between the joints of the stone; and the author estimates that as a result of 43 years of erosion, six of the stones of the apron, which may be taken as a sample, had lost the following amounts respectively:—45, 60, 48, 50, 37, and 58 per cent.

2. "On the Physical Geology of Tennessee and adjoining Districts in the United States of America." By Prof. Edward Hull, M.A., LL.D., F.R.S., F.G.S., late Director of the Geological Survey of Ireland.

The area described in the paper is occupied by the Unaka or Blue Ridge, which may be regarded as one of the parallel ridges of the Alleghanies, and the prolongation of Prof. J. D. Dana's "Archæan Protaxis." It runs in a general south-westerly direction, and attains an elevation of 6760 feet. At its base, and to the north-west of it, is the Valley of East Tennessee, about 40 miles wide, and furrowed by north-east and south-west ridges and depressions, parallel to the strike of the Cambrian and Silurian beds. Through this runs the Tennessee River, which, instead of running south to the Gulf of Mexico, turns to the north-west, some distance below Chattanooga, and cuts through the Cumberland table-land, a prolongation of the Appalachian mountains, and flows into the Ohio River.

The Cumberland table-land has an average height of 2000 feet above the sea, and 1350 feet above the Tennessee River at Chattanooga. It consists of a synclinal of Carboniferous rocks resting conformably upon the Devonian beds, and is bounded along the East Tennessee Valley by a curved escarpment; a similar though more indented escarpment forming its north-western margin, and separating it from the Silurian plain of Nashville. The table-land is about 40 miles wide, and is intersected by the valley of the Sequachee River, running in a north-easterly direction along a subsidiary anticline from near Jasper for a distance of sixty miles.

From the base of the Cambrian beds, the whole Lower and Upper Palæozoic formations succeed each other in apparently conformable sequence, except at the junction of the Upper and Lower Silurian series, where a probable discordance occurs. The prolonged period of subsidence and deposition at length gave way to elevation; acting with the greatest effect along the Alleghanies. Under these circumstances, denudation proceeded most rapidly along the tract bordering the Protaxis, whilst the synclines were protected from erosion to a greater degree; and as the elevatory movement was more rapid along the Unaka range, the flow of the streams was generally westward. At a later period the Cumberland plateau began to be formed by backward erosion of the strata in the direction of the dip; so that it owes its development to the erosion of the Tennessee and Clinch Rivers on the one hand, and to the Cumberland River on the other. Where the Tennessee River flows in a north-westerly direction through the Cumberland plateau, the divide between it and the Gulf of Mexico is only 280 feet above the river-bed, whilst the table-land is 1400–1500 feet above. The author infers, therefore, that when the river began to erode its channel, the plateau was relatively lower than the tract to the south of the present course of the stream, but that by denudation the relations have been reversed, whilst the river has never left its originally selected course.

The author compares the state of things with that which must have occurred in the case of the northerly rivers running from the centre of the Wealden axis; but mentions that Prof. Safford and Mr. J. Leslie account for the Cumberland plateau by faulting, though he thinks that the well-defined escarpment along the valley of East Tennessee seems to show that this cause is insufficient.

In conclusion, he believes that the denudation was accelerated during the pluvial or "Champlain" period, and calls attention to the "Columbia formation" on the east side of the Alleghanies, and to the deposit of red loam by which the surface of the country of the valleys of the Tennessee and Sequachee is overspread, and which is probably referable to a similar stage.

3. "On certain Ornithosaurian and Dinosaurian Remains." By R. Lydekker, Esq., B.A., F.G.S.

The author is indebted to Professor O. C. Marsh for the correct determination of the bones described in the paper.

1. *Ornithosaurian Quadrates.*—The reptilian bones in the British Museum, Nos. 43034, 44183, and 41179, are Ornithosaurian quadrates. The two latter belonged to the right side of the skull. The distal extremity of each forms a deeply grooved oblique trochlea, above which is a nearly quadrangular shaft. To the inner side of this shaft is attached, by suture, a flattened plate of bone, concave internally, and convex externally, representing part of the pterygoid; so that the relation of the quadrate to the pterygoid in the *Ornithosauria* is the same as in the *Rhynchocephalia.*

The smaller quadrate would agree approximately in relative size with the so-called *Pterodactylus Manseli,* Owen, and the larger more nearly with the so-called *Pt. suprajurensis,* Sauvage, both of which may be provisionally referred to *Rhamphorhynchus.*

2. *Tibia of Cœluroid Dinosaur.*—The author would provisionally refer the right tibia of a small Dinosaur from the Wealden of the Isle of Wight, which had been incorrectly referred to *Hypsilophodon,* to the species originally described, from an examination of two vertebræ, as *Calamospondylus Foxi,* but which he would now name *Calamosaurus Foxi.* It presents striking avian affinities.

CORRESPONDENCE.

PROF. BONNEY AND GENERAL McMAHON ON THE GEOLOGY OF THE LIZARD DISTRICT.

Sir,—In your last issue, Prof. Bonney in his characteristic style refers to my late work in this district. He, however, at once, falls into error as to the number of my communications to the Magazine. there being five, not four as stated by him. The one he overlooks being that "On the Schists of the Lizard District," April, 1890, perhaps the one he likes least.

As to the points in his letter under his figures 1, 2, 3 and 4, I have no doubt but that Prof. Bonney will in good time demonstrate these assertions; but in the meanwhile they are only assertions. I will freely and gladly admit the errors, both in my observations and inductions, when proofs are forthcoming. I was much amused by General McMahon's letter. I am well aware (perhaps before the General was) of the apparent sequence of the various rocks laid down by the masterly mind of De la Beche, and also (perhaps) I have seen more of the true dykes in the Lizard District than has fallen under the observations of General McMahon. There are dykes, however, that I regard as of contemporaneous or segregation origin.

Independent of the sequence of the rocks referred to, I think them the product of eruptions of one geological period, that intermittent action is noticeable, and that there is a decided passage of the main masses into each other, and that the same magma, cooling under different conditions, has given rise to many varieties of rock. My communications were intended to lead up to this point.

As to my theory of the origin of the "banded structure," let it with the others "sink or swim." I care not which survives.

As to the close of General McMahon's letter, I much regret having to say, that I think it is quite uncalled for.

TORQUAY, 9TH *December*, 1890. ALEXR. SOMERVAIL.

REPORT OF THE INTERNATIONAL GEOLOGICAL CONGRESS.

SIR,—I am periodically asked by friends who joined the last Geological Congress how it is that the promised report to which each member was said to be entitled has not yet appeared, although some of us paid an additional subscription to expedite its production.

Ought not the eminent geologists whose names appeared on the circular inviting support to that Meeting to be asked to furnish some explanation for this unaccountable delay? (B.V)^2.

ON DYNAMO-METAMORPHISM.

SIR,—I certainly had no thought of "rolling back the development of chemical theory a few decades at least," when I wrote of energy taking "the molecular forms of heat and chemical action." Dr. Irving in his criticism of this expression leaves out my reference to heat. I conclude therefore that he has no objection to that part of the statement. As to the assertion that part of the energy, which previously existed in the molar form, was converted into the "molecular form of chemical action," I was unable to know whether Dr. Irving's stricture expressed the generally received views upon the subject, owing to my imperfect acquaintance with chemistry. I have, therefore, consulted the highest authority on such questions to whom I could apply and on whose opinion I can place reliance. With respect to Dr. Irving's apparently general statement, that "chemical combination must generate heat," he replies, that, "when carbon is heated in carbonic acid gas, C O is formed with a disappearance of heat; and, when nitrogen and oxygen are sufficiently heated together, an oxide of nitrogen is formed with a disappearance of heat; and, that in these cases the heat which has disappeared has become chemical energy in the molecules of C O or N O. Whether it be *atomic* energy or not is not at present known, but as the molecule includes the atoms, it is certainly "molecular" as distinguished from ordinary mechanical, or molar energy. Since many chemical changes, which only take place at very high temperatures, appear to be attended with a disappearance of heat, it is at least not improbable that some of the changes, by which minerals are formed in the interior of the earth, may also be attended with a storage of energy."

"Perhaps Dr. Irving takes exception to the supposition that mechanical energy may be directly transformed into chemical energy. If so, you may reply that the known effects of pressure upon chemical changes, when those changes are attended by a change of volume, afford support to the supposition. Recent observations on the influence of surface tension on chemical change by Liebreich, J. J. Thomson, and others, lead in the same direction, so that it cannot be said that the supposition is unreasonable, even in the light of recent advances in physical chemistry."

Finally I am told that the assertion that "chemical combination must generate heat" is certainly incorrect, and that the examples CO and NO to the contrary are "only two out of an immense number."

HARLTON, CAMBRIDGE, 13 *Dec.* O. FISHER.

DYNAMOMETAMORPHISM.

SIR,—I must apologize to Dr. Irving for having overlooked the observations to which he refers. Unfortunately I had not read the work in question at the time when I wrote my letter.

As regards the main subject of his letter in your December number, I would offer only a few words. In assuming that the whole of the work done in the compression, deformation, and friction of rock-masses passes into heat, Dr. Irving misses the idea which underlay the whole of my remarks, and was more explicitly stated in Mr. Fisher's article. The *direct* correlation of mechanical and chemical energy was, I believe, first mooted by Dr. Sorby in 1863; but the practical verification of it rests on such experiments as those of Cailletet, Pfaff, and Spring. To take an example: Spring subjects a mixture of sulphur and copper filings to a pressure of 5000 atmospheres, and finds it converted into crystallised copper sulphide. The operation is conducted slowly, and the temperature of the apparatus kept constant. In other words, so much of the mechanically-developed energy as takes the form of heat is carefully removed; but chemical combination still takes place. It follows that the energy absorbed in this combination comes directly from the mechanical work done, without the intervention of heat.

ST. JOHN'S COLLEGE, CAMBRIDGE. ALFRED HARKER.

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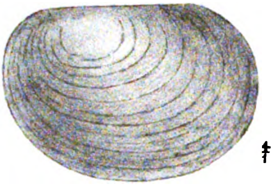

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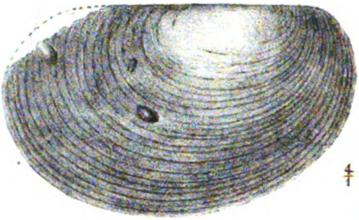

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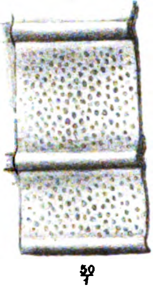

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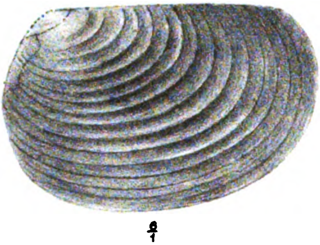

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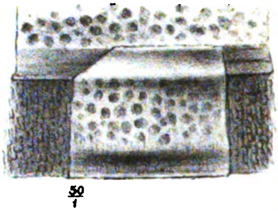

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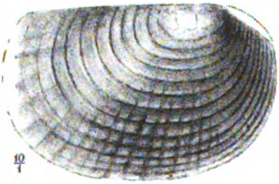

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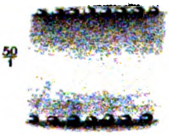

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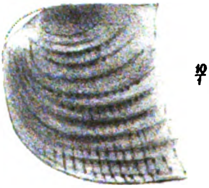

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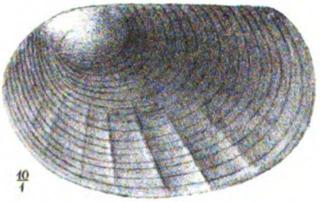

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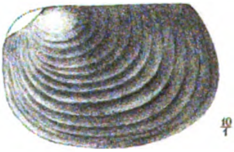

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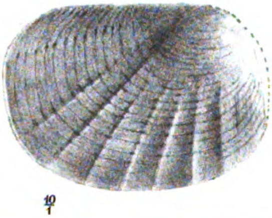

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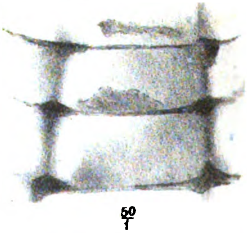

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FOSSIL ESTHERIÆ.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VIII.

No. II.—FEBRUARY, 1891.

ORIGINAL ARTICLES.

I.—On some more Fossil Estheriæ.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

(PLATE II.)

Introduction.
Estheria membranacea of the Old Red, Orkney.
Estheria Andrewsii of the Purbeck, Wilts.
Estheria Hindei of the Trias, Pennsylvania.
Estheria minuta (*Germari*?) of the Trias, Saxony.
——— ——— var. *Brodieana* of the Trias, Cheshire.
Estheriella.
Estheriella costata } of the Trias, Saxony.
Estheriella nodocostata } of the Trias, Saxony.
Bibliographic history of the *Estheriellæ*.

In the September Number of the Geological Magazine, 1890,[1] I offered some notes on certain Triassic *Estheriæ* of North America and Bavaria, and on an *Estheria* from the Purbeck strata of Wiltshire. An interesting example of *E. membranacea* from the Old Red of Orkney was figured, but not described. We have now the Rev. W. R. Andrews's other Purbeck *Estheria*, referred to at p. 389, ready for description; another Triassic *Estheria* from Pennsylvania; and some most interesting specimens of the rare *Estheriella*, instituted as a subgenus by the late Professor Dr. Ch. Ernst Weiss.

Seeing the account of *Estheria Lewisii* in the Geol. Mag., *loc. cit.*, Dr. G. J. Hinde, F.G.S., remembered some specimens he had collected in Pennsylvania, and these I find to be from the same place (Phœnixville) as supplied Mr. C. M. Wheatley with a series for my Monograph in 1862; but Dr. Hinde's examples show structure not seen in any of the others.

Having met with a peculiar structure in some Carboniferous *Estheriæ* from Scotland, which seemed to correspond with the descriptions of that in *Estheriella,* I asked the late Prof. E. Weiss for information on the subject; and, though confined to bed by illness, he most courteously gave his attention to my request, and not only sent me (in February, 1890) some specimens of the rare fossil, but obtained permission, from the Director of the Geological Institute and Mining Academy at Berlin, for me to have on loan some of the best specimens from the Geological-Survey Museum, to figure and describe. I deeply regret that we have to bring out the results of the examination without consultation with Prof. Weiss, whose death a large circle of friends and admirers had to deplore last summer.

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[1] Decade III. Vol. VII. pp. 385–390, Pl. XII.

Of *Estheria minuta* and some other forms of that genus I gave some notes in the GEOL. MAG. Decade II. Vol. V. 1878, pp. 100–102, Pl. III. Figs. 1, 2, and now, besides the notices referred to above, I have to make mention of Mr. C. E. De Rance's discovery of this species in the lower part of the "Keuper Marls" of Cheshire,—a lower horizon for England than had been previously known.

1. ESTHERIA MEMBRANACEA (Pacht). GEOL. MAG. September, 1890. Pl. XII. Fig. 9.

Jones, Monograph of the Fossil Estheriæ, Pal. Soc. 1862, pp. 14-22, pl. i. figs. 1–7.

Length 6 (hinge-line 5), height 4 mm.

This little fossil has been noticed by P. N. Wenjukoff in his Memoir "On the Fauna of the Devonian System in North-western and Central Russia," 8vo. St. Petersburgh, 1886, pp. 223–4 (in Russ). In the synonymy he gives *Posidonia aspera*, Kutorga, 1852, instead of "*Posidonomya rugosa*, Kutorga," of the list at p. 14 of the "Monograph Foss. Estheriæ." We may note that Raimund Pacht in the "Archiv Natur. Liv.-, Ehst- und Kurlands," vol. ii. 2nd part, 1859 ("1861" in Wenjukoff's list, *op. cit.* p. 224), treating of the Devonian Limestone in Livland (Livonia), describes and figures *E. membranacea*, at pp. 290–291, and in figs. 7*a*, *b*, *c*, of the plate (not numbered), as "*Posidonia membranacea*, n. sp.=*P. rugosa*, Kut., auf der Karte des St.-Petersb. Gouv."

It was remarked at p. 21 of the "Monogr. Foss. Esth." that in the Russian (or rather Livonian) specimens "the thin upstanding concentric riblets are better preserved than in the flagstones of Caithness." Some individuals, however, from Orkney, collected by Mr. Jex, and now in the British Museum, show the ornamentation so clearly that Fig. 9 of Pl. XII. in the GEOL. MAG. for September, 1890, was specially given, though not described at the time, only alluded to at p. 390. This figure not only shows the longer, or more oblong, shape of the valve, referred to in the "Monograph" at pp. 14 and 15, but a very delicately reticulate interstitial sculpturing, such as was supposed (at pp. 15 and 19) to have been modified by the impress of sand grains in the matrix at Caithness.

2. ESTHERIA ANDREWSII, sp. nov. Pl. II. Figs. 1–4.

Fig. 1.—Length 8·5 (hinge-line 6), height 6 mm.
Fig. 2.— „ 11·5 („ 9), „ 7 mm.

These specimens, from the Purbeck beds of the Vale of Wardour, as also those described in the GEOL. MAG. for September, 1890, p. 389, Pl. XII. Figs. 1, 2, were collected by the Rev. W. R. Andrews, F.G.S., in a quarry at Teffont-Ewyas, Wilts, but in a different stratum of the Middle-Purbeck formation, namely, in a dark shaly clay, containing *Cypridea fasciculata* and *C. punctata*, five feet below the horizon of the *Estheria* referred to above.

The former specimens were referable to *E. subquadrata* (Sow.), by their shape and ornament; but those now under notice are larger; one individual is approximately subquadrate in shape (Fig. 1), but the other is more elongate (Fig. 2); both have the umbo further from the anterior extremity, and otherwise differ from *E. subquadrata* and *E. elliptica* in being less fully curved at the antero-ventral region and in being higher behind than in front. Further, they have a delicate reticulation for the interstitial ornament (Fig. 3). This finely punctate sculpture, however, belonging to the superficial layer of the test, gives an impression on the matrix, at some places, of a delicate linear granulation, making very small, vertical, interrupted striæ; whilst the inside of this outer layer shows a coarser pitting (Fig. 4).

Specimens numerous, squeezed flat, but fairly well preserved, on the thin laminæ of a bluish grey, soft shale, with brownish partings, and with white patches of the decomposed *Cyprideæ*.

3. ESTHERIA HINDEI, sp. nov. Pl. II. Figs. 5–8.

Length 7 (hinge-line 5), height 4·5 mm.

An elegant suboblong *Estheria*, boldly rounded in front, narrower behind; rather more than half egg-shaped in a longitudinal aspect. Umbo at the antero-dorsal corner. Concentric riblets (15 visible) strong and far apart, and at some spots seen to be neatly beaded, but rarely so regularly and distinct as in Fig. 6. The interspaces are bare of ornament; but the inner layer of the test in some instances shows irregular vertical rows of small lumpy elevations (Fig. 7), which are probably exaggerations (in the older part of the valve) of small vertical irregular bars (Fig. 8), in the interspaces elsewhere. This last-mentioned columnar ornament is analogous to that shown in fig. 37, pl. ii. of the Monogr. Foss. Estheriæ, and referred to at page 387, GEOL. MAG. September, 1890.

The specimens under notice are numerous in a hard, black, thinly-laminated Triassic shale, from Phœnixville, Pennsylvania (Dr. G. J. Hinde's Collection), like some of that described at p. 99, "Monogr. Foss. Estheriæ," as having been supplied by Mr. C. M. Wheatley from the same locality. Some are better preserved as to shape; but others more distinctly show the structure of the valve. The selected specimen, Fig. 5, is like one of the "narrower" examples mentioned at p. 98 *op. cit.*; and, as with many others, there is no interstitial ornament. In some shiny, black, filmy valves we have the features shown in Figs. 6, 7, 8. The last two belong to the inner layer of tests of apparently different ages, but covered with the outer layer, in which the ornament became obsolete. Hence neither figs. 29 and 30, nor fig. 31 of pl. ii. "Monogr. Foss. Esth." must be taken by themselves for specific characters, though suggested at p. 386 of the GEOL. MAG. Sept. 1890.

These specimens from Pennsylvania certainly differ from *Estheria ovata* of the "Monogr. Foss. Esth." p. 84, pl. ii. figs. 26–28, being proportionally longer, and having a less fully semicircular ventral outline. They are larger and proportionally higher (broader) than

E. Lewisii, Geol. Mag. Sept. 1890, p. 385, Pl. XII. Fig. 3, with the umbo further forward and a different ornament. Otherwise these two species, as well as *E. multicostata* (Emmons), "Monogr. Foss. Esth." p. 86, fig. 6, and *E. ovalis* (Emmons), *op. cit.* p. 87, fig. 8, are evidently allied forms, though the last two have most probably been badly drawn.

4. Estheria minuta (Alberti), 1832. Pl. II. Fig. 12.

Jones, Synonymy in the "Monograph of the Fossil Estheriæ, Palæont. Soc. 1862," p. 42; F. von Alberti's "Ueberblick über die Trias," etc., 1864, pp. 191 and 192; Jones, Geological Magazine, Dec. III. Vol. VII. 1890, Pl. XII. Figs. 4–8.

Length 3·0 (hinge-line 2·0), height 1·9 mm.

This is a specimen occurring in the Lower-Bunter shale at Dürrenberg, in Saxony, with *Estheriella costata*, Weiss. It is very much like it, as seen in Fig. 9, but is smaller and has no radial striæ. It has the same number of concentric lines, and therefore cannot be the young of the larger form; and the occurrence of the radii is too persistent among the many *Estheriellæ* in the shale, to allow of the supposition that they constituted merely a casual feature and were not always present in the same series of valves. Fig. 12 may be compared with fig. 8 of pl. v. and fig. 29, and even with fig. 28, of pl. i. of the "Monogr. Foss. Esth." as a specially straight-backed form of the species.

Fig. 12 may possibly be *Estheria Germari* (*Posidonia*, Beyrich, Zeitsch. D. g. Ges. vol. ix. 1857, p. 377), from the Bunter at the Steinberg, north of the Hartz, and at Halle and Dürrenberg, both in Saxony. Andrae, in the Explanation of the Geological Map of Halle, 1850, p. 67, referred to it as *P. minuta*. It is characterized by having a long and straight hinge-border; and according to Prof. Weiss it has no radial markings.

Besides the authors treating of the occurrence of *Estheria minuta* in the German Trias that are enumerated in the "Monogr. Foss. Esth." pp. 44 *et seq.*, we should mention C. von Schauroth, Zeitsch. D. g. Ges. vol. ix. 1857, p. 99 (Coburg).

4°. Estheria minuta (Alberti), var. Brodieana, Jones. Pl. II. Fig. 14.

Monogr. Foss. Estheriæ, 1862, p. 69, pl. ii. figs. 8–15, and pl. v. fig. 10; Geol. Mag. Dec. 3, Vol. VII. 1890, p. 388, Pl. XII. Fig. 6.

Length 3 (hinge-line 2), height 2·5 mm.

Lately Mr. C. E. De Rance, F.G.S., has obtained from the "Old Alderley Quarry," at Alderley Edge, Cheshire, a small shoal-like group of *Estheriæ* in a soft, dull red, finely micaceous shale, belonging to the upper part of the "Keuper Marls," f. 6 of the Geological Survey Map, and a thousand feet lower down in the Trias (being below the waterstones, f. 5) than any of the English examples of *E. minuta* yet found.

The specimens occur both as single valves and in open pairs;

they are much crushed, and Fig. 14 shows one of the best. It is very much like the German specimen figured in the GEOL. MAG. for September, 1890, Pl. XII. Fig. 6, and nearly matches fig. 9 of pl. ii. "Monogr. Foss. Esth."

E. minuta, var. *Brodieana*, has been reported by Ferd. Roemer as having been found in the Keuper of Upper Silesia. This, and some other notes on the occurrences of *E. minuta* published since 1862, are given in the GEOL. MAG. Dec. II. Vol. V. 1878, p. 102.

E. minuta, var. *Karpinskiana*, Jones, related to var. *Brodieana*, was obtained by Dr. Karpinsky from the Triassic or Rhætic strata of Troizk, on the eastern side of the Ural. See Ann. Mag. Nat. Hist., October, 1883, p. 244, pl. vi. fig. 1.

ESTHERIELLA, Weiss (as a subgenus, 1875).

Similar to *Estheria*, excepting that the valves bear radial riblets or slight ledges crossing the concentric striæ from near the umbo to the ventral border.

5. ESTHERIELLA COSTATA, Weiss, 1875. Pl. II. Figs. 9, 10, *a*, *b*.

Posidonomya Wengensis, Giebel (non Wissmann). Zeitsch. gesammt. Naturwiss. Halle, 1857, p. 308, pl. ii. fig. 6.

Estheria ? Wengensis, Alberti. Ueberblick Trias, etc., 1864, p. 192. *note*.

Estheria (*Estheriella*) *costata*, Weiss. Zeitsch. D. g. Gesellsch. vol. xxvi. 1875, p. 711, *note*.

Estheriella costata, Zittel. Handbuch der Palæontologie, vol. i. Lief. 8, 1885, p. 568.

Fig. 9.—Length 3·7 (hinge-line 2·7), height 2·4 mm.

Valves like those of *Estheria minuta*, such as those shown by pl. i. fig. 29, and pl. v. figs. 8 and 9, "Monogr. Foss. Esth.," that have markedly straight backs, a more or less definite postero-dorsal angle, and strong concentric lines of growth (about 13 visible). Modifications produced by pressure, as well as by variable conditions of growth, make it difficult to find perfectly comparable specimens among fossil *Estheriæ*. The characteristic feature is the presence of numerous (about 20 or more) oblique striæ radiating from the middle region to the ventral and posterior borders. Posteriorly they produce a series of undulating wrinkles, crenulating the edge; but more forward they seem to have been little furrows formed by the notches in the edge of each successive overlapping lamina of the test, and giving a minute tile-like appearance to that part of the surface. A pattern somewhat like this, but on a still smaller scale, is visible in *Estheria tegulata* from the Scotch Coal-measures, to be published in the Trans. Geol. Soc. Glasgow, vol. ix. pl. v. fig. 6*b*.

In the *Estheriella* under notice the edge of each lamina is more or less thickened at and between the notches, and was there sufficiently produced as little hollow tubercles to leave the minute pits seen in the inside of the test (figs. 10 *a*, *b*). Here, also, there are traces of this structure reaching further up towards the umbo than on the outside (Fig. 9).

The specimens of both this and the next species are very delicate and scarcely ever perfect films of valves in bluish grey shale.

Some of the radials at their intersections of the lines of growth retain thin brownish relics of the test; but otherwise the valves are represented by partial moulds and casts, much flattened.

Both come from the Lower Buntersandstein of Dürrenberg, Saxony.

The specimens figured were courteously lent by the Director of the Geological Survey [1] at Berlin, at the instance of the late lamented Prof. Dr. Ch. E. Weiss, who also gave me some other specimens, collected by himself at Dürrenberg on the road to the Amtsberg, May, 1875.

6. **ESTHERIELLA NODOCOSTATA** (Giebel), 1857. Pl. II. Figs. 11, 13.

Posidonomya nodocostata, Giebel. Zeitsch. gesammt. Wissensch. Halle, 1857, p. 309, pl. ii. fig. 7.

Estheria ? nodocostata, Alberti. Ueberblick Trias, etc. 1864. p. 193, *note*.

Estheria (*Estheriella*) *lineata*, Weiss. Zeitsch. D. g. Gesellsch. vol. xxvi. 1875, p. 711, *note*.

Fig. 11.—Length 4·2 (hinge-line 2·7), height 2·5 mm.
Fig. 13. „ 3·5 („ 2·3), „ 2·4 mm.

Valves like those of the foregoing species, ovate-oblong in shape, with long, straight dorsal border; umbo quite forward; postero-dorsal angle usually pronounced; ends well rounded; the posterior curve larger than the anterior; ventral border gently curved. Concentric lines numerous and rather feeble. Radial riblets few (about 9), but much stronger than in *E. costata*, being definitely raised ridge-like wrinkles wide apart (Figs. 11 and 13). On the inside of the valve (Figs. 13 *a*, *b*) there is a little pit wherever the radial crosses a concentric stria, as if the edges of the successive laminæ of the test had been slightly raised just there, so as to leave a little hollow below. The specific name applied by Giebel to this form evidently has reference to this feature, as seen in Fig. 13 *a*. Locality and collection the same as mentioned with the foregoing species.

To make the history of the two foregoing species complete, the following extracts are taken from the published memoirs concerning them.

1857. Ch. G. Giebel, Palæont. Untersuchungen; Zeitschrift für die gesammten Naturwissenschaften, Halle, 1857, October u. November, Nos. x. xi. pp. 301-318.

Posidonomyœ [*Estheriœ*] in the Bunter Sandstone near Dürrenberg, p. 308, pl. ii. figs. 6 and 7.

P. Wengensis, p. 308, pl. ii. fig. 6. Gr. Münster, Beit. Petrefkd. iv. p. 23, pl. 16, fig. 12. Not far from *P. minuta*, but with fine radial lines from umbo to border. Wissmann has not noted this [?]; but it is conspicuous as a characteristic [none given in fig. 6; nor is the size mentioned]. [Some true *Posidonomyœ* are then compared.]

P. nodocostata, n. sp., p. 309 (fig. 7), as the other species may be called, which occurs with *P. minuta* in two specimens from the depth of 612 feet in the bore-hole No. 3, near Dürrenberg, is long-oval in shape; 1½‴ long, and not quite 1‴ high; convex; rather smaller in front than behind; ventral border convex; the umbo distinct and rounded. There are seven radials (three of them in front, two in the middle, and one behind) reaching the border. An eighth appears to follow the hinge-line backwards. About sixteen regular, parallel, concentric lines cross the radials, and lose themselves in a series of roundish knots. The shell is very thin, of a dark horn-colour, quite like that of the associated *P. minuta*.

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[1] Königl. geol. Landesanstalt und Bergakademie, Invaliden Str. 44, Berlin.

The relative size shown by Fig. 6 (about 2 mm., instead of 13 mm., ½ inch), and the recognition of its alliance to and occurrence with *E. minuta*, make it probable that the *P. Wengensis* of Giebel is an *Estheria*, and different from the *P. Wengensis* of Wissmann, as intimated by von Alberti.

1864. Dr. F. von Alberti. Ueberblick über die Trias, etc., 1864. (See also GEOL. MAG. 1878, p. 102.)

p. 192, *note.—Posidonomya Wengensis*, Giebel (not *P. Wengensis*, Wissmann, which is much larger), may be an *Estheria* near *E. minuta*, distinguished by weak radial lines.

p. 193, *note.—P. nodocostata*, Giebel; from 192 m. depth in bore-hole No. 3, near Dürrenberg; long-oval 0·003 m. long, and 0·002 m. high. Probably a crustacean.

P. minuta is a crustacean; so is probably *Posidonia Albertii*, Voltz, probably the same as *Posidonomya Germari*, Beyrich [Zeitsch. D. g. Ges. vol. ix. 1857, p. 377].

1875. E. Weiss. Zeitsch. D. g. Gesellsch. vol. xxvii. 1875, pp. 711, 712.

From the Lower Buntersandstein of Dürrenberg on the Saale, in Saxony, some small shells are described as being in size and condition like *Estheria Germari* of Beyrich, and occurring with it, but differing from it by having a certain number of riblets radiating from the umbo, and thus constituting a new type. It is remarked that Giebel had already described two species from Dürrenberg, with the names of *Posidonomya Wengensis* and *P. nodocostata*, which may perhaps be identical with the above mentioned. The two latter came from a boring; but the foregoing were found in the shales outcropping between the sandstone on the Saale, in the road above the Salt-works of Herr Director Metzner, and the bore-hole. When not well preserved, the valves lose their riblets near the umbo and on the front and hind borders; but these remain strongest and most distinct in the ventral region. In good specimens these two kinds of ribbing are readily recognized; one kind consisting of about 12 riblets, of which the middle 6–10, very sharply defined and wide apart, occur on the convex face, and are hollow on the inside of the valve, as furrows, proportionally distant with smooth spaces between, broken only by concentric wrinklings. This form may answer to *P. nodocostata*, Giebel, which, however, seems to have only 7 riblets.

The other species shows very numerous riblets, thickly set, more particularly towards the front and ventral borders; these are less sharp, and almost equal in breadth with the spaces between them. In particularly well-preserved specimens about 30 were counted, in others 20; but the number is difficult to determine; and we must recognize the difference of the two forms in the above-mentioned characters. This second species is evidently the *Wengensis* of Giebel. *Note* at p. 711.—Dr. E. Weiss named the first of the two foregoing species *Estheriella lineata*, and the latter *E. costata*; but he had a doubt about the naming, and thought that these names should be withdrawn until perfect proof of the difference between his and Giebel's species should be arrived at.

Dr. E. Weiss, though inclined to look on these two forms as belonging to a new genus, thought that it might suffice, with their great resemblance in general habit to *Estheria*, to place the radially-ribbed shells of Dürrenberg as a subgenus only, with the name *Estheriella*.

For the form with about 12 ledge-like riblets (*E. lineata*, Weiss, the *nodocostata* of Giebel), he gives—

		mm.		Proportion.
The height to the breadth (length)	=	2·8 : 4·3	=	1 : 1·5
„ „ „		3·2 : 4·3	=	1 : 1·3
„ „ „		2·7 : 3·5	=	1 : 1·3

For the form with over 20 riblets and furrows (*E. costata*, Weiss, the *Wengensis* of Giebel),—

		mm.		Proportion.
The height to the breadth (length)	=	2·5 : 3·8	=	1 : 1·5
„ „ „		2·4 : 3·5	=	1 : 1·4
„ „ „		2·3 : 3·3	=	1 : 1·4
„ „ „		2·2 : 3·1	=	1 : 1·4

Near Dürrenberg there are other horizons of *Estheria*. In the boring they are found at a depth of about 200 mètres; near the Royal Saltworks were found some very small *Estheriæ* (without riblets[1]), also on the left bank of the Saale, some feet below the first coarse white sandstones of the Middle Buntersandstein, at the cliff between Graslau and Leina, near Corbeth.

NOTE.—*E. nodocostata* (Giebel) retains its name, the form being recognized as that which Giebel figured and described in 1857. His *Wengensis*, however, is not the *Posidonomya* so named by Wissmann; nor is it from Wengen; and the name proposed by Weiss, namely, *costata* (though too near to *nodocostata* for convenience), should take its place.

In the "Mémoires du Comité Géologique," 4to. St. Petersburg, vol. vi. 1888, P. Kratow describes and figures two small bivalves with radial striæ as *Estheriella trapezoidalis*, pp. 469 and 557, pl. ii. fig. 27, and *E. oblonga*, pp. 470 and 557, pl. ii. fig. 28 (reaching

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[1] Fig. 12 of Pl. II. may be one of these small *Estheriæ*, possibly *E. Germari*, Beyrich.

5 mm. in length), from the Permian beds of Tscherdyn on the Kolwa, on the western side of the Ural.

EXPLANATION OF PLATE II.

Fig. 1.	*Estheria Andrewsii*, sp. nov.	Left valve of the short form; magn. 4 diam.
,, 2.	,, ,,	Right valve of the long form; magn. 4 diam.
,, 3.	,, ,,	Portion of surface; magn. 50 diam.
,, 4.	,, ,,	Another part of the surface, showing the inside of one layer, the impression of its outside on the matrix (dark); magn. 50 diam.
,, 5.	*Estheria Hindei*, sp. nov.	Left valve; magn. 6 diam.
,, 6.	,, ,,	Portion of the beaded concentric striæ; magn. 50 diam.
,, 7.	,, ,,	Portion of an interspace; magn. 50 diam.
,, 8.	,, ,,	Portion of two interspaces; magn. 50 diam.
,, 9.	*Estheriella costata*, Weiss.	Right valve; magn. 10 diam.
,, 10.	,, ,,	*a*, Part of the inside of a right valve; magn. 10 diam. *b*, Portion of the same; magn. 50 diam.
,, 11.	*Estheriella nodocostata* (Giebel).	Left valve; magn. 10 diam.
,, 12.	*Estheria minuta* (Alberti).	Possibly *E. Germari* (Beyrich); magn. 10 diam.
,, 13.	*Estheriella nodocostata* (Giebel).	*a*, Inside of left valve; magn. 10 diam. *b*, Portion of the same; magn. 50 diam.
,, 14.	*Estheria minuta*, var. *Brodieana*, Jones.	Left valve; magn. 5 diam.

II.—On the British Earthquakes of 1889.[1]

By Charles Davison, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

I PROPOSE in this paper to write a short account of the earthquakes that have been felt in Great Britain during the year 1889, and to consider the relations of these earthquakes with the geological structure of the districts in which they occurred. The attempt seems to me worth making, for two reasons. The first is that, though few in number and slight in intensity, the earthquakes which visit this country are individually and in their connexion with preceding shocks, of considerable interest. And, secondly, the accounts, even when published, are widely dispersed, and, appearing chiefly in local newspapers, become difficult of access in after years. I believe, therefore, that an attempt to collect and discuss these scattered observations cannot be without some value.

I will. in the first place, describe the nature of the evidence on which these accounts are founded. For the two more important earthquakes, the chief authorities are the newspapers published within and near the disturbed areas. In a few cases, the notices they contain are far from satisfactory, and bear obvious signs of exaggeration.[2] But, in certain respects, their evidence seems to be trustworthy; and, as a general rule, I believe we may rely on them for a knowledge of the places where a shock was or was not felt, of the places where it was accompanied by the characteristic earthquake sounds, and also for a record of the effects of the shock sufficient to enable us to determine its intensity according to the Rossi-Forel scale.

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[1] A paper read before the Royal Society, June 19, 1890, and published in abstract in the Roy. Soc. Proc. vol. 48, pp. 275–277.

[2] For example, the statement that, during the Edinburgh earthquake of Jan. 18, a boy was thrown out of bed at Gogar, is evidently inaccurate.

In many cases, however, this evidence has been supplemented by inquiries made in the several districts or by letters addressed to the local newspapers asking for further observations. The accounts I have thus received, being generally replies to a few definite leading questions, are often of considerable value; and I should like to take this opportunity of again thanking the ladies and gentlemen who have in this way rendered me such courteous and serviceable assistance.

In the description of each earthquake, the heading contains its name and date, the name being taken from that of the district principally affected by the shock. The time of occurrence is given in Greenwich mean time, the hours being numbered from 0 to 24. The intensity is determined by means of the Rossi-Forel scale, a translation of which is given below. This scale is very generally adopted by Italian and Swiss seismologists, and, though rough and undoubtedly variable to a slight extent, is well suited to the nature of the evidence at our disposal, the range of variability of any degree of the scale being probably less than the limits of error of ordinary observations.

Rossi-Forel Scale of Intensity.[1]

I. Recorded by a single seismograph, or by some seismographs of the same model, but not by several seismographs of different kinds; the shock felt by an experienced observer.

II. Recorded by seismographs of different kinds; felt by a small number of persons at rest

III. Felt by several persons at rest; strong enough for the duration or the direction to be appreciable.

IV. Felt by persons in motion; disturbance of moveable objects, doors, windows, cracking of ceilings.

V. Felt generally by every one; disturbance of furniture and beds, ringing of some bells.

VI. General awakening of those asleep; general ringing of bells, oscillation of chandeliers, stopping of clocks; visible disturbance of trees and shrubs. Some startled persons leave their dwellings.

VII. Overthrow of moveable objects, fall of plaster, ringing of church bells, general panic, without damage to buildings.

VIII. Fall of chimneys, cracks in the walls of buildings.

IX. Partial or total destruction of some buildings.

X. Great disasters, ruins, disturbance of strata, fissures in the earth's crust, rock-falls from mountains.

The disturbed area is defined as that at every point of which the earthquake-shock is felt. The form and position of its boundary must therefore depend on the practice of observers and on their power to detect a feeble shock; but, as a knowledge of this boundary can possess but little value when it does not represent an isoseismal line, I have endeavoured to draw it on the earthquake maps so as to pass as nearly as possible through places where the intensity was the same.

The epicentrum of an earthquake is the projection of the seismic focus or centrum on the surface of the earth. To determine its position, three methods have been proposed, depending respectively on observations of the direction, intensity, and time of occurrence of the shock in different parts of the disturbed area; but the second method alone is applicable to the earthquakes here discussed. It will be seen, on reference to the maps which accompany this paper, that the isoseismal lines are approximately circles or ellipses of small eccentricity; and I have assumed that the epicentra coincide nearly with the centres of these areas. The correctness of the position so assigned to an epicentrum depends not only on the accuracy with which the isoseismal lines are traced, but also on a further assumption that their form is not greatly altered by variations in the nature of the rocks within the disturbed area. Also, if the seismic focus, as in the case of a fault, be inclined to the horizon, the intensity must, *cæteris paribus*, be greater on the side towards which the fault slopes; so that the epicentrum is probably nearer the

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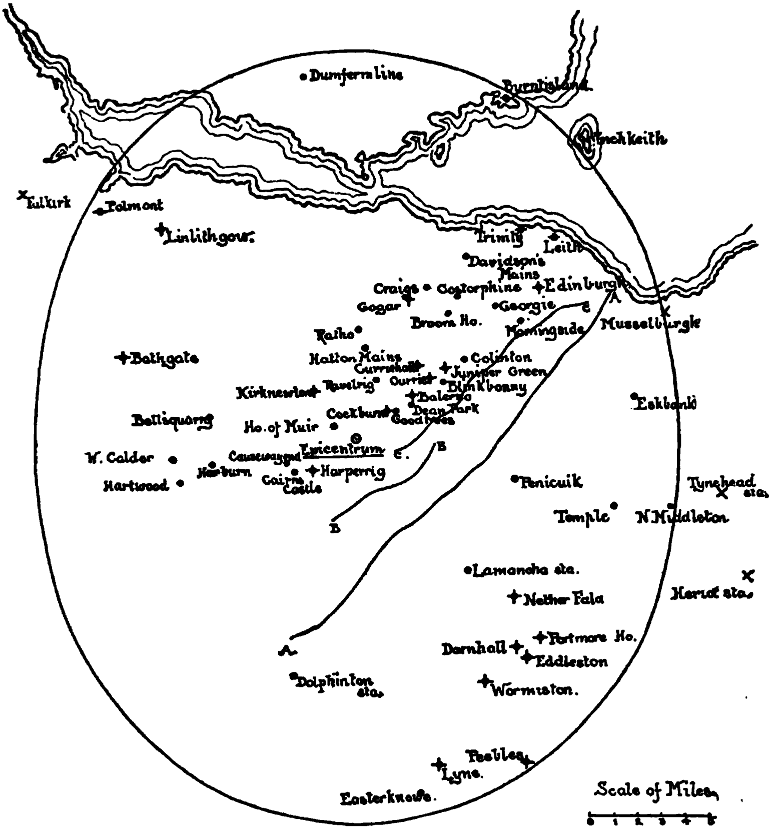
[1] M. S. de Rossi. Bull. Vulc. ital., anno. iv. (1873), pp. 39–40; F. A. Forel, Arch. des Sc. phys. et nat., 3me pèr. t. xi. pp. 148–149.



Edinburgh Earthquake: January 18. 1889.

intersection of the focus with the earth's surface than would be indicated by the above method. Nevertheless, for the majority of British shocks, the assumption seems to me admissible, for the isoseismal lines in all the cases here considered are of small dimensions, and there is no evidence tending to prove any marked irregularity in their form. I believe that the true positions of the epicentra cannot differ by more than a mile (if by so much) from the positions indicated for the four principal earthquakes considered in this paper.

In two cases I have attempted to assign the origin of the earthquake to the impulsive friction along well-known and prominent faults. In each case, the evidence, being cumulative and far from abundant, is by itself certainly not conclusive; and the deductions made from it can only be regarded as at best but highly probable. Taken as a whole, however, the reasons for connecting the majority of non-volcanic earthquakes with such a cause are so weighty, and the theory is so comprehensive of apparently disconnected phenomena, that the inferences referred to are invested with a higher degree of probability than that with which they would otherwise and separately be endowed.[1]

The slow dying-out vibrations of very distant shocks are frequently propagated to this country, and are registered by magnetic and other recording instruments. More rarely are felt the perceptible vibrations of earthquakes that are less distant, but still extra-British, in their origin, *e.g.*, the earthquake of May 30, 1889, which disturbed the Channel Islands, the South of England, and the North of France. To include either kind of shock would unduly extend the limits of this paper, and I have therefore confined myself to the consideration of earthquakes whose epicentra are situated within the area of the British Islands.

Of these, there were at least five during the year 1889; namely, on Jan. 18 in the neighbourhood of Edinburgh; on Feb. 10 in Lancashire and parts of the adjoining counties; on May 22 on Ben Nevis; on July 15 in Kintyre, Gigha Island, and Arran; and on October 7 in the east of Cornwall. In addition to these, there were three others, the seismic origin of which is at present doubtful, or which rest on the evidence of one observer only.

1. EDINBURGH EARTHQUAKES: JAN. 18, 1889.

At least two shocks were felt at, and in the neighbourhood of, Edinburgh on this day, the first at about 4h. 10m., and the second at 6h. 53m. The time of occurrence of the former is variously given, but, as a rule so approximately, that it is very doubtful whether the existence of several separate shocks can be inferred. This may have been the case, but I do not think that the evidence is sufficient to prove that there was more than one shock preceding that which took place at 6h. 53m.

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[1] It may be well to remark here, that, excepting the sections on the geological relations of the earthquakes, the following accounts were almost entirely written, the isoseismal lines were drawn upon the maps, and the positions of the epicentra determined, before any reference whatever was made to the geological maps of the disturbed areas.

First Shock.

Time of occurrence, about 4h. 10m.; Intensity, about V.

Very few observations were made on this shock, and I have only met with one detailed account, which I owe to the kindness of a correspondent in Edinburgh. It is impossible, therefore, to determine the boundary and extent of its disturbed area or the position of its epicentrum.

The only records I possess of this shock are from Edinburgh, Broomieknowe, Penicuik, and Bellsquarry; and these are all within, and several miles from, the boundary of the disturbed area of the second shock.

The recorded times of occurrence are: Edinburgh, about 2h., about 4h., and at 4h. 10m.; Broomieknowe, about 2h.; Penicuik, about 3h. and about 4h. 50m.; and Bellsquarry, at 5h. Most of these seem to be mere guesses. I have selected 4h. 10m. as probably the most correct time. It was obtained by reference to a clock almost immediately after the event, and was given to me by the correspondent mentioned above, who also estimated the time of the second shock as about 6h. 50m.

The intensity was probably about V.; but this estimate must be regarded as doubtful, as it is made from only one observation, and this at a place which may have been some distance from the epicentrum. At Edinburgh, my correspondent informs me, it was strong enough to make the bed rock: "the bed-room door shook, its handle rattled briskly and noisily and forcibly, and the glass above shook also."

A rumbling sound was heard at the time of the shock at Edinburgh; and at Broomieknowe a hollow noise was heard, but the shock itself is not recorded as having been felt there.

Second Shock.

Time of occurrence, 6h. 53m.; Intensity, VI.; Epicentrum, about 3 miles W. 42° S. of Balerno.

Disturbed Area.—The evidence for the study of this earthquake is much more abundant. I have altogether 93 independent observations, made at 53 different places. A large number, however, are from Edinburgh, and the rest, unfortunately, are not very evenly distributed over the disturbed area. On this account, the south-west portion of its boundary can only be drawn approximately.

An excellent account of the earthquake was given in the "Scotsman" for the following day, but in this attention was naturally directed chiefly to the places where the more striking phenomena were observed. With hardly an exception, the local newspapers fail to supplement this evidence as regards the limits of the disturbance; and I have therefore been obliged to rely principally on the accounts given to me by correspondents, and these, though of great value, are of course not numerous. With reference to the southern part of the area, however, the case is very different.. For all the evidence from this part of the district, I am indebted to the kindness and courtesy of Dr. C. B. Gunn, of Peebles who, at the cost of much time and trouble, sent me a report on the observations of the earthquake made in and near the north of Peeblesshire. I shall have occasion to refer again to this report, the value of which it would be difficult to over-estimate.

The outline of the disturbed area as drawn upon the accompanying map, is slightly elliptical in form. How far this outline may be considered as accurate will be partly evident from an inspection of the map, on which all places at which the shock was certainly felt are marked with small black discs, and those where there is good reason for believing that it was not felt with small crosses (+).[1] There can thus be little doubt about the form of the boundary from the neighbourhood of Polmont, by Dumfermline, Burntisland, Musselburgh, and Tynehead station, to Peebles; but, for the rest of the area, its course is less certain. I have made several inquiries in this part of the district, but entirely with negative results. From the intensity of the shock at the nearest places at which it was felt, I do not think, however, that the form of the boundary can differ very greatly from that laid down on the map, unless, owing to peculiar local conditions, the earth-vibrations were quenched more rapidly in the south-west quarter than elsewhere.

The disturbed area as thus defined is about 30 miles from north to south and 26½ miles from east to west, and contains an area (including the part occupied by the Firth of Forth) of about 830 square miles. Its boundary corresponds to an isoseismal line of intensity less than V., but decidedly greater than IV. The centre of the curve is about 3 miles W. 42° S. of Balerno.

It is worthy of notice that in Edinburgh, where the intensity was V., the shock was not felt by any one on the Castle Hill, nor at the Observatory on Calton Hill. The geological structure of the district may also account for the shock not having been felt at Inchkeith, and not having been recorded as felt within a large part of the area occupied by the Pentland Hills.

Time of Occurrence.—Omitting all confessedly approximate determinations of the time of occurrence, the following definite records have been made: Edinburgh, 6h. 50m., 6h. 52m., and 6h. 54m. or 6h. 55m.; Penicuik, 6h. 52m.; Leith, 6h. 53m. 15s. ± 10s.; Trinity (near Leith), 6h. 54m. ± ½m.; Harperrigg and Peebles, 6h. 55m. These estimates, with one exception, are not exact enough to be used for ascertaining the velocity of the earth-wave or the position of the focus. Probably the most correct of these times is that given for Leith; it was determined by Mr. G. Redpath. "I immediately turned round," he says, "and noted the time, which I found was 53 minutes 15 seconds past six by a clock in my sitting-room. On going to verify it by an astronomical clock in another room, I found to my regret that I would have to allow a margin of about ten seconds—earlier or later." This is sufficient, however, to determine the *epoch* of the shock. I have given it as 6h. 53m., but, as Leith is about 12 miles from the epicentrum, it may have been a few seconds earlier.

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[1] To the south of Peebles, owing to the small scale of the map, I have been obliged to omit the indication of a number of places where, as Dr. Gunn's inquiries show, the shock was not felt.

Nature of the Shock.—For descriptions of the nature of the shock, I have to rely chiefly on newspaper accounts, and these, as a rule, are far from being either exact or detailed.

In most parts of the disturbed area, it would seem that the shock was noticed as a single oscillation, the observers in some cases feeling as if the bed or chair on which they rested were slightly raised and then lowered. A few compare the sensation to that of passing over a wave in a small boat.

From at least five places, however, there come accounts of a second oscillation immediately following the first; as if there were two prominent vibrations, while the commencing and concluding tremors were generally imperceptible. These places are Edinburgh, Leith, Ratho, Balerno, and Peebles. But it should be noted that all observers at these places did not detect the second oscillation; and this was probably owing to the latter being, as one observer at Edinburgh states, slighter than the first. At Balerno, again, it was remarked that, though both movements were momentary, the second was the more lasting of the two.

There is only one other noteworthy point that I can gather from the somewhat scanty descriptions. In all the instances, but one, in which the character of the movement is recorded, the oscillation is described as a rise of the ground, followed by a fall. This is the case at Edinburgh, Balerno, Trinity (near Leith), Davidson's Mains, Linlithgow, and Polmont. On the other hand, at Penicuik, a "workman, who happened at the moment to be seated, felt the brick floor recede from his feet, and then, as it were, return to them." Now, the six places just mentioned are in the northern part of the disturbed area; whilst Penicuik is a short distance to the east of the epicentrum. I shall recur to this point in discussing the origin of the earthquake.

Duration.—Records of the duration come from seven places, and range from not greater than one second (at Davidson's Mains), to about two seconds (at Edinburgh, Trinity, Leith, and Penicuik), and about three seconds (at Balerno and Kirknewton). Probably some of the estimates of the duration also include that of the sound-phenomena; but, in either case, they seem to indicate a decrease in duration as the disturbance radiated from the origin.

Intensity.—The following list gives the intensity of the shock at places where the accounts were sufficiently detailed for its determination.

VI. Balerno, Currie, Harperrigg.

V. Bellsquarry, Corstorphine, Davidson's Mains, Eddlestone, Edinburgh, Gogar, Hartwood, Juniper Green, Kirknewton, Leith, Linlithgow, Penicuik, Ratho.

IV. or V. Bathgate, Polmont.

IV. Burntisland, Causewayend, Cockburn, Dumfermline, Eskbank, Peebles.

These observations are not sufficiently numerous to enable isoseismal lines to be drawn with any accuracy. But it is evident that the isoseismal of intensity V. could not be very distant from the boundary of the disturbed area, as drawn upon the map. We may therefore conclude that this boundary corresponds to an isoseismal of intensity between IV. and V., and probably nearer V. than IV.

Sound-phenomena.—All the places where the characteristic earthquake-sounds are known to have been heard are marked on the map with a small cross (+) through the spot indicating the position of the place. They are unfortunately very few in number, only 19 out of the 53 places from which records have been received. But, on the other hand, there are several places where the shock was felt, and where it is expressly stated that no sound was heard. These are Leith, Trinity, Burntisland, and Polmont, and they are indicated on the map by a stroke (—) drawn through the spot representing the place. It is also important to note that, whilst records from Edinburgh (where the intensity was V.) are numerous, 28 in number, in only two cases is there any mention made of earthquake-sounds. Again, at Peebles (where the intensity was IV.) out of four separate accounts which Dr. Gunn sent me, two are records of the sound-phenomena only, the shock being apparently not felt in these cases. From these facts, two conclusions may be drawn:

(1.) The area throughout which the sounds were heard was not coextensive with the disturbed area; a fact previously noticed in the case of other earthquakes.

(2.) The centre of the sound-area was not coincident with that of the disturbed area, but lay probably about 2½ miles to the south or south-east of the latter. It will be seen that a similar inference may be made in the case of the Lancashire earthquake of Feb. 10. I believe that this conclusion is new, and will be found to throw light on the origin of earthquake-sounds.

In their character the sounds accompanying the Edinburgh earthquake do not seem to have been in any way unusual. The following are the only detailed descriptions I possess:

Balerno: like the falling of a heavy mattrass.

Bathgate: as if a heavy waggon had passed along the street.

Cockburn: as though a large tree had fallen near the house.

Edinburgh: (1) like the rumbling of a passing coach; (2) a loud sharp crash, as if the door had been slammed in an extraordinary manner.

Harperrigg: like the firing of a time-gun twice, accompanied with an oscillation.

Kirknewton: a loud clanking noise.

Linlithgow: a suppressed rumbling sound.

Peebles: like the passing of a heavy cart.

Ratho: like the passing of a heavy traction-engine.

In every place the duration of the sound seems to have been very short. This is evident from some of the above accounts, and probably, as before remarked, the duration of the sound is included in the estimates of the duration of the shock given above. The sound is generally said to have accompanied the shock, but this is a vague expression. Probably it overlapped the shock slightly at either end; at different places in and near Peebles, Dr. Gunn informs me that it was said in one case to precede the shock, in two to follow it, and in one to both precede and follow it.

Position of the Seismic Focus and Geological Relations.—The faults of the Edinburgh district "group themselves naturally into two series, one more or less at right angles to the strike of the beds, that is, east and west, or from south-east to north-west; the other usually of greater magnitude, in long parallel north-east and south-west lines." The latter faults "lie almost wholly along the axis of the Pentlands. In place of cutting across the strike of the country as the other faults do, they run parallel to it. Flanking each side of the anticline, their effect has been to depress the Carboniferous strata against the older rocks of the hills, so that on the west side their downthrow is to the west, and on the east side to the east." Of these main faults, which are four in number, three are shown on the accompanying map of the Edinburgh earthquake. The first of these (marked AA on the map) extends from the sea at Portobello to beyond Carlops in Peeblesshire; its downthrow is to the south-east, and the amount of the throw in parts probably not less than 3000 feet. The second fault (BB) reaches from the head of the Logan valley to North Black Hill, where it seems to die out. The third fault (CC) extends in a wavy line from Arthur's Seat, near Edinburgh, to the neighbourhood of Bevelaw; but in certain parts its course is somewhat doubtful. The downthrow of the two latter faults is to the north-west, but the amounts of their throw are unknown.[1]

Now, the centre of the disturbed area, as indicated on the map, lies about 3 miles W. 42° S. of Balerno; and this, as before remarked, may be regarded as the approximate position of the epicentrum, which is therefore to the north-west of all three of the faults. The earthquake cannot, then, have any connexion with the first of these faults. From the line of the third fault (CC), the perpendicular distance of the epicentrum is about 1½ miles. The shock might apparently have been caused by a slight extension of the fault towards the south-west, or by a slip of the fault, supposing it to extend underground far enough in this direction. But, unless we assume that the earthquake originated at one fault, and the earthquake-sounds at exactly the same moment at another, it does not seem possible to connect the earthquake with this fault; for the centre of the sound-area lies about two or three miles to the south or south-east of the epicentrum, and therefore to the south or south-east of the line of fault at the surface.

Turning next to the second fault (BB), we find the perpendicular distance of the epicentrum from the line of fault at the surface is about 2½ miles; and this would admit of the sound-focus being on the fault-plane, but probably close to the surface. It does not seem unreasonable to infer, then, that the Edinburgh earthquake was in some way connected with this fault.

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[1] H. H. Howell and A. Geikie, Geology of the Neighbourhood of Edinburgh, pp. 118–119.

If the inclination of the fault were known in the neighbourhood of the epicentrum, this would enable us to determine approximately the depth of the seismic focus, assuming the inclination to be constant to a depth of a few miles below the surface. The exact inclination is, however, unknown; but Prof. J. Geikie informs me that it "cannot be less than 70°–80° from the horizontal, say, about 15° from the vertical." If this be the case, then, the depth of the centre of the seismic focus is not much less than 6 miles, nor much greater than 12¾ miles, and perhaps does not differ considerably from 8⅖ miles.

The bearing of the observations made on the first direction of motion of the principal vibration will now be obvious. The six places (Edinburgh, Balerno, Trinity, Davidson's Mains, Linlithgow, and Polmont) where the movement was first upward, lie on the downthrow side of the fault, whilst Penicuik, where the movement was downward first, is on the upthrow side. Now, if the mass of rock on the downthrow side slipped slightly downwards, or if the mass on the upthrow side slipped upwards, the particles on the downthrow rock-face would be drawn upwards first, and those on the upthrow rock-face would be drawn downwards. The earth-wave or the rock-masses on either side of the fault would thus start in opposite phases of vibration, and the resulting effects at the seven places on the surface would be those described above.

I believe we may, then, with some probability, conclude: (1) that the Edinburgh earthquake was caused by a slip of the fault marked BB on the map, at a spot vertically below the position indicated for the epicentrum, and therefore not far from the middle of the fault, where, probably, the throw is a maximum and where earthquake-action has been most frequent or most intense; (2) that, on account of the simple character and short duration of the disturbance, the horizontal length of the fault over which the slip took place was very short, possibly less than a mile; (3) that the slip of the downthrow side was downwards or that of the upthrow side upwards, resulting, in either case, in an increase of the throw of the fault in the neighbourhood of the seismic focus; and (4) that, while the region of maximum slip, the focus of the earthquake proper, was probably at a depth of several (perhaps about 8) miles, the slip extended upwards to within a short distance of the surface, this part of the slip-area being the focus of the sound-vibrations. This latter conclusion will be considered somewhat more fully in treating of the Lancashire earthquake, and at greater length in a subsequent paper.

"When we reflect," says Dr. A. Geikie, "upon the extent of depression produced by these faults, we see at once that the Carboniferous rocks must formerly have stretched across the area of the Pentland Hills, and that it is to the agency of these dislocations,

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[1] On the Existence of Undisturbed Spots in Earthquake-shaken Areas, Geol. Mag. (April, 1886), Vol. III. pp. 157–159.

aided subsequently by an extensive denudation, that the older rocks of that chain are visible."[1] The Pentland faults have thus played an important part in the past history of the district. But their work is not yet finished, and the occurrence of the Edinburgh earthquake shows that the process of geological change is still being carried out on the same lines as before. It remains for future earthquakes to enable us to determine the laws which govern these changes and the rate at which they are now taking place.

Authorities.—"Dalkeith Advertiser," Jan. 24; "Dumfermline Journal," Jan. 26; "Falkirk Herald," Jan. 19; "Lanarkshire Examiner," Jan. 26; "Peeblesshire Advertiser," Jan. 26; "Scotsman" (Edinburgh), Jan. 19, 21, 22, 23, 25, and Dec. 28; "West Lothian Courier" (Bathgate), Jan. 19 and 26.[2]

For other information contained in the above account, I have pleasure in thanking the following gentlemen: Mr. J. Aitken, F.R.S., Prof. R. Copeland, F.R.S.E., Dr. G. Craigie (Musselburgh), Mr. W. Dick (Tynehead Station), Dr. John Doig (Bathgate), Prof. J. Geikie, F.R.S., Dr. C. B. Gunn (Peebles), and the Rev. W. Ross (Polmont).

(*To be continued.*)

III.—AN INEXPENSIVE APPARATUS FOR THE ISOLATION OF MINERALS BY MEANS OF HEAVY LIQUIDS.[3]

By J. W. EVANS, LL.B., B.Sc., F.G.S.;
Demonstrator in Geology, Royal College of Science, London.

I AM aware that in describing a new apparatus for separation by heavy liquids, I am adding another item to a list which is already a very long one. My only excuse is that this particular form has the advantage of being easily and cheaply constructed from ordinary chemical apparatus, and yet has most of the advantages of Thoulet's[4] comparatively expensive form.

The construction and use will be best explained by means of the accompanying drawings.

A is a cylindrical funnel. The conical portion connecting the upper cylinder with the narrower cylinder or tube below, should be as steep as possible, otherwise a little trouble is occasioned by particles adhering there.

The funnel is closed below by means of a piece of india-rubber tubing and pinchcock. It may be supported on an ordinary wooden filter stand.

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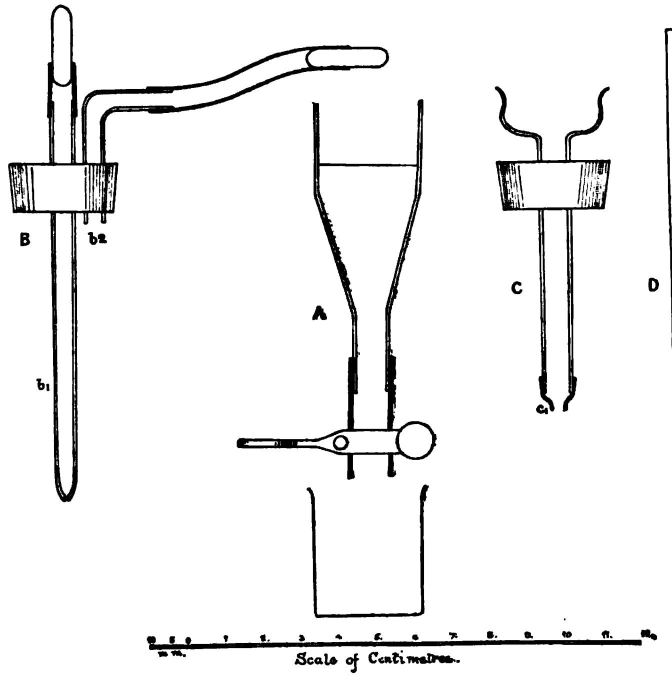
[1] Geol. of the Neighbourhood of Edinburgh, p. 120.

[2] The following papers contain descriptions of the Edinburgh earthquake:—A. G., The Earthquake at Edinburgh, Nature (Jan. 31, 1889), vol. 39, pp. 324-325. R. Richardson, On the Earthquake Shocks experienced in the Edinburgh District on Friday, January 18, 1889 (read before the Edinburgh Geol. Soc. on Feb. 21, 1889), "Scottish Geographical Magazine" for March, 1889.

[3] A short notice of my apparatus in its simplest form will be found at p. 108 of the interesting and valuable Manual by Professor Cole, of the Royal College of Science, Dublin, entitled, "Aids to Practical Geology," which has just been published.

[4] Bull. Soc. Min. de France, t. ii. (1879) p. 17.

B represents a long glass tube (b_1) passing through the centre of a cork. At the lower end the tube is brought to a blunt point, in which is a minute aperture. After being drawn out to a point, the end must be carefully heated again so as to thicken the glass round the hole without closing it entirely. Unless this is done, the point of the tube is apt to break off. This tube can be closed above by india-rubber tubing and a short piece of glass rod. The cork is also perforated (as shown) by another tube (b_2), which can be closed in a similar manner.



The liquid and the material to be operated on are placed in the funnel. When the first separation has taken place, the apparatus *B* is inserted, the point of b_1 should reach down close to the pinchcock. b_1 is left open at the top, and b_2 is connected with an air-pump, which should be very cautiously worked and the pressure diminished so that a gentle stream of bubbles passes from the opening at the end of b_1. The particles are thus thoroughly shaken; the lighter fragments that have been carried with the heavier, or *vice versâ*, are disengaged.

The upper end of b_1 is now closed and the air is exhausted so as to get rid of any air attached to the grains. The apparatus may then be separated from the air-pump by compressing the india-rubber tube attached to b_2 and at the same time disconnecting the end and inserting the piece of glass rod. After the lapse of some time air is re-admitted through b_2.

The above processes may be repeated several times, if thought necessary; to more thoroughly shake the lighter fragments, the tube b_1 may be raised till the end is only just below the liquid.

If an air-pump is not available, the air may be withdrawn by the lungs, but the effort to overcome the weight of the column of liquid is apt to render the passage of air rather violent. The tube b_1 may also be used (without the cork) to agitate the lighter layer by gently blowing just below the surface; or to disturb any fragments resting on the conical part of the apparatus, which may be best done by drawing up a portion of the liquid and then letting it descend from the tube close to the fragments to be moved; but it is safer to use a pipette for this purpose.

A few lighter particles may adhere to the tube as it is removed; if it is desired not to neglect these, they may be washed back by liquid of the same density.

In order to draw off the heavier particles, the apparatus *C* and *D* is used. *C* is a thistle-tube perforating a cork, and having at the lower end a piece of india-rubber tube (c_1) of less diameter when unstretched than *C*. The india-rubber at the end of *C* fits tightly into the top of the narrow portion of *A*. *D* is a glass rod brought to a conical point at the lower end. Insert it in *C* so that the end projects some distance beyond the india-rubber c_1, in which it should fit tightly. The whole is then inserted in the funnel. If this is done skilfully, few (if any) of the lighter particles are carried down with it, as the conical end of the glass rod causes a centrifugal movement at the surface as it passes down. To remove any that may have descended, adjust the cork so that the india-rubber is a little above the narrow portion of the funnel; a little movement and the lapse of a few minutes will be sufficient. If any particles are caught by the lower end of the india-rubber c_1, they may be displaced by an up-and-down movement of the rod *D* relatively to *C*. Now depress *C* so as to fit tightly in the narrow portion of the funnel, tighten the cork, withdraw the rod *D*, and open the pinch-cock; the lower part of the liquid falls with the heavier fragments into a beaker; the tube is then thoroughly washed clear of all residuary particles by a stream of distilled water poured into the cup of the thistle-tube *C*.

After letting the tube drain till nearly free from water, the pinch-cock having been closed, and the tube *C* removed, the density may be lowered for another separation; this is best done by gradually adding the diluting fluid through b_1 or a similar tube, the small aperture being at the bottom of the narrow portion of the funnel. The thin stream of lighter fluid easily mixes with the heavier as it rises, especially if the tube is being gently agitated.[1]

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[1] I have not arranged for the calculation of density from the volumes used. If required, the apparatus could be graduated (being heightened if necessary). Practically it is better to dilute with a solution only slightly lighter till separation takes place and then determine the density by one of the usual methods.

The above form is adapted for use with Klein's solution (Borotungstate of Cadmium), which has been found the best for practical use for densities below 3·28, as it has not the highly poisonous character of the Sonstadt solution (potassium iodide and mercuric iodide) and does not decompose and discolour so easily as methylene iodide. Above 3·28, methylene iodide, with or without the addition of iodoform (as proposed by Retgers),[1] must be used. Here, as the use of india-rubber is inadmissible, the pinchcock must be replaced by a glass tap (but the bore need not be the same as that of the glass tube, as is usually necessary in apparatus of this nature); and instead of using the india-rubber c_1, the end of the thistle-tube *C* and the base of the conical part of the funnel must be ground so as to fit one another, and the rod *D* must closely fit the tube.

The tube *C* has some external similarity to the plug used in the useful apparatus devised by Mr. Smeeth;[2] but there the plug is not perforated, and there is no resemblance in the mode of action of the two forms.

I ought to add that all my work with heavy liquids has been carried on at the Royal College of Science, where Professor Judd has kindly given me every facility in my endeavours to find the best practical form of instrument neither too expensive nor too delicate for students' work.

IV.—ESSAYS IN THEORETICAL GEOLOGY.

By R. D. OLDHAM, A.R.S.M., F.G.S.,
of the Geological Survey of India.

THE AGE AND ORIGIN OF THE HIMALAYAS, WITH ESPECIAL REFERENCE TO THE REV. O. FISHER'S THEORY OF MOUNTAIN FORMATION.

The Facts (*continued from p.* 18).

I HAVE already shown that the northern boundary of the Indo-Gangetic alluvium is a structural one, and that the rock area immediately to the north of it has been elevated, while the nature of the boundary on the south, the deep imbayments of the alluvium, the gentle manner in which the older rocks slip under it, and the inliers, alike show that, on the south, the alluvium has gradually encroached on the rock area by the subsidence of the latter.

I have also shown that at one period the present demarcation of the Peninsular and Extrapeninsular areas did not exist, and that the latter extended across the area now occupied by the Gangetic alluvium into what is now Sikkim. From this we may conclude that during the rise of the Himalayas the formation of the depression now occupied by the alluvial deposits of the Indus and Ganges has proceeded, and that, just as its northern boundary has been encroached upon by the gradual southward extension of the Himalayan region, so it has itself encroached on the rock area to the south, and necessarily at a greater rate.

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[1] J. W. Retgers, Neues Jahrbuch, 1889 (2), p. 185.

[2] Scientific Proceedings of the Royal Dublin Society, vol. vi. (new series 1888), p. 58.

If this hypothesis is true, the sections of deep borings near either limit of the alluvium should show diverse results as to the relative proportion of fine to coarse-grained deposits near the surface and further down. On the north, the southward march of the edge of the hills would lead to coarse-grained deposits extending over finer, while near the southern margin the increasing distance from the edge of the rock area should lead to fine-grained deposits being laid down over coarser.

The deep borings, which have been put down in the Gangetic alluvium, are few in number, and, except two, are not well situated for testing the hypothesis.

The first of these is the boring made in Fort William, Calcutta, in 1836–38. In discussing this and the other borings I shall adopt the method of classifying the beds passed through as "sand" and "clay." A more perfect classification is impossible, owing to the vagaries of nomenclature indulged in by the men, never trained geologists, to whom the sinking of the borings must necessarily be entrusted. By classifying "sand," "coarse sand," "clayey sand," etc., as sand; and "clay," "silt," "sandy silt," "limey silt," etc., as clays, we shall get a very fair general idea of the relative coarseness of grain of the beds passed through in different parts of the same boring.

Adopting this system of classification, we may make an abstract of the Fort William boring[1] thus:—

ft.		ft.	sand	clay
0	to	100	0	100
100	,,	200	11	89
200	,,	300	95	5
300	,,	400	98	2
400	,,	481	81	0

The increase in coarseness of grain of the beds passed through is conspicuous enough in this abstract, but the reality is even more striking, for, in the sand from 180 feet downwards, some beds of gravel and pebbly sand are included, and the boring was finally brought to a standstill in a bed of gravel which it was not found possible to penetrate.

The second boring of importance is that made at Umballa.[2] Adopting the same broad classification of clay and sand, we get the following result:—

ft.		ft.	sand	clay	
0	to	100	59	37	soil 4
100	,,	200	56	42	kunkur 2
200	,,	300	58	42	
300	,,	400	54	46	
400	,,	500	46	54	
500	,,	600	37	63	
600	,,	701	6	95	

Here we have, as the hypothesis requires, a very distinct increase in coarseness of texture in the upper beds as compared with the lower.[1]

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[1] For detailed section see Rec. Geol. Surv. Ind. vol. xiv. p. 221 (1881); Calc. Journ. Nat. Hist. vol. i. p. 324 (1841).

[2] Rec. Geol. Surv. Ind. vol. xiv. p. 233.

Besides these two borings, one has been put down at Agra, the evidence of which is slightly vitiated by the peculiar local conditions. The abstract of the section is as follows:[2]—

ft.		ft.	sand	clay	kunkur
0	to	100	65	35	0
100	„	200	44	56	0
200	„	300	0	97½	2½
300	„	400	18	76½	5½
400	„	481	7	74	0

Here there would seem to be an increase of coarseness of texture, both upwards and downwards, from 200 feet. The explanation of this, I apprehend, is to be found in the fact that the surface deposits round Agra are largely composed of blown sand; and it is probable that the sand beds found in the uppermost 160 feet of the section are of æolian origin, while below that the beds are alluvial and exhibit the gradual upward increase in fineness of texture required by the hypothesis.

A fourth boring has lately been sunk to a depth of 1336 feet at Lucknow. As might be expected from its situation, "there is no marked increase or decrease in the coarseness of the beds passed through; but, near the bottom of the boring, some beds of coarse sand were found, and these may indicate an approach to the base of the alluvium and mark a time when its southern boundary was not far from Lucknow."

To sum up, of the four deep borings which have been made, two are completely in accordance with the hypothesis; one is in favour of it, though its evidence is vitiated by peculiar local conditions; while the fourth is so situated as to give no evidence one way or the other till it is carried to a greater depth. Stronger proof is at present impossible, and we may accept the hypothesis as a true one.

To summarize the history of the Himalayas as revealed by their geology, we find that at the commencement of the Secondary period the Himalayan system of disturbance had not commenced; that, some time towards the end of the Secondary period, it originated near the middle of the range and gradually extended outwards, reaching the country now accessible to observation in the North-western portion of the Himalayas, about the commencement of the Tertiary period; that the beds had, at this epoch, undergone but little disturbance and contortion, while such compression as they had been subject to did not belong to the Himalayan system of disturbance. From this time onwards the beds have been continuously subject to compression, contortion, disturbance and elevation, and the Himalayas have been continuously an area of denudation.

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[1] On a former occasion (Rec. Geol. Surv. Ind. vol. xviii. p. 118) I was misunderstood when urging this argument; it was pointed out that Umballa is peculiarly situated in an area which receives no coarse deposit; that, at an equal distance from the foot of the hills, large boulders were found in the foundations of the railway bridge over the Jumna; and it was urged that the section was consequently irrelevant. Owing to this I must here point out that the argument is by no means affected by the greater or less average coarseness of texture of the deposits on other sections, as it only claims that on any individual section near the northern limit of the plains the beds near the surface will, on the average, have a greater coarseness of texture than those which underlie them.

[2] For detailed section see Rec. Geol. Surv. Ind. vol. xviii. p. 121.

As soon as the Himalayas were defined as a distinct hill range, a series of subaerial deposits of great thickness began to be deposited in a region of subsidence along their outer edge, and the demarcation between the areas of subsidence and deposition on the one hand, and of elevation and denudation on the other, was abrupt, exhibiting itself at the present day as a gigantic fault. As the Himalayas rose, the boundary between the two areas advanced step by step to the southwards; the beds which had been deposited along the foot of the original hills were compressed, disturbed, elevated, and, consequently, exposed to denudation; but the new limit between the area of elevation and of depression was again an abrupt one, which, on a subsequent further advance of the hill area, showed itself as a fault with an upthrow towards the central range. Concurrently with this southward march of the margin of the Himalayas, the depression occupied by the Indo-Gangetic alluvium extended itself to the southwards by the gradual subsidence of the peninsular rock area.

Such are the main features of the history of the Himalaya. As I have shown, there have probably been minor elevations of the range unaccompanied by disturbance; but, in the main, its elevation is the direct result of, and has been accompanied by, compression and contortion of the beds of which it is composed.

II.—*The Theory.*

It is now generally admitted that the elevation of what may be called true mountain ranges is but a secondary effect of that compression which their structure shows they have undergone. There is also a general concensus of opinion in favour of the Herschel-Babbage doctrine that denudation and elevation, deposition and subsidence, are closely connected with each other, at least in so far that denudation acts in intensifying the effect of the causes which lead to elevation, and deposition of those that lead to subsidence.

The most recent and complete adaptation of this doctrine to the theory of mountain formation is contained in the Rev. O. Fisher's work on the "Physics of the Earth's Crust." Mr. Fisher's hypothesis demands a solid crust resting on a denser magma, whose condition is actullay or virtually that of a fluid. The crust, on being subjected to compression, yields along certain lines and as a result is thickened, both upwards and downwards, from a zone somewhere in the thickness of the crust "above which the material will on the average be sheared upwards, and below it downwards;" this zone is called the "neutral zone," and, for reasons which it is needless to enter into here, is placed at three-fifths of the thickness of the crust from its upper surface.[1]

As, for many reasons, it is highly improbable that the elevation would be perfectly symmetrical, we may assume that the watershed would be nearer one side than the other, and, consequently, a larger amount of debris removed by denudation would be deposited on the opposite side of the ridge, with the result that the centre of gravity would be shifted towards that side on which the greater quantity of sediment is deposited, that is, to the right of the diagram, Fig. 1. In this state the centres of gravity and of flotation, are no longer in the same vertical, and equilibrium is only restored by a rotation of the disturbed tract accompanied by an extension of the depression to the right and a diminution and ultimate extinction of that to the left. Along with this rotation there would be a general shifting of the tract to the right, which would expose the left-hand side to tension, "which may possibly open fissures downwards on the western side of the range."

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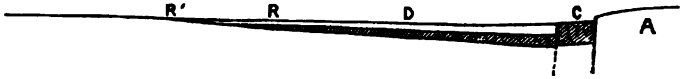
[1] Physics of the Earth's Crust, second edition, pp. 183–184.

FIG. 2.



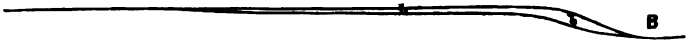


FIG. 1.

FIG. 1.—Fisher's Physics of the Earth's Crust. Diagram on p. 186. 2nd edition.

FIG. 2.—Diagram to illustrate the theory of the elevation of the Himalayas. scale: hor. about 60 miles, vert. about 30 miles to 1 inch.

A.—Massif of the Himalayas.
B.—"Root" of the same.
C.—Earlier marginal deposits, compressed and elevated.
c.—Continuation of the same, depressed and undisturbed.
D.—Subsequent deposits overlapping C.
b.—Sinking of lower surface of crust due to C and D.

The extinction of the Nummulitic sea of the central Himalayas and the great volcanic outbursts which accompanied it may represent the extinction of the depression on the left-hand side of the diagram, but the greater part of the elevation of the Himalayas having taken place since this, we are at once encountered by the difficulty that the hypothesis requires a rotation of the whole of the Central Asian plateau. We have no reason to suppose that so large a mass of the earth's crust would have a rigidity sufficient to allow of its rotation as a whole; on the contrary, there is every reason to suppose that it would yield infinitely to any long continued stress. In Mr. Fisher's investigation it is, however, assumed that all lateral pressure is relieved before the action of denudation commences. Such a simplification of the conditions is essential to a mathematical investigation; but as in the case of the Himalayas the compression has lasted up to the recent period, while there are not wanting indications that it is still in progress, we may take it that the state of things which the latter part of Mr. Fisher's investigation deals with has not yet been reached, and we may consequently neglect all considerations connected with the rotation of the Himalayan tract of elevation.

We have now to consider what modifications are required to fit the purely mathematical theory to the more complex conditions of actuality. In the first place the elements of rigidity and rotation being abandoned, we need not consider the left-hand side of the diagram, and may redraw it in greater accordance with the conditions of the Himalayan region. (See Fig. 2.) We have now an elevated region *A A* subjected to denudation, and adjoining it an area extending to *R*, on which deposition is taking place, the deposits being contributed by the elevated ground *A* to the north, and the waste of the rock area to the south. The tract being supposed to be in equilibrium, as *A* is lightened by denudation, the surplus floating power of B will cause it to rise, and the load thrown on *D* will cause it to sink, especially in the neighbourhood of *A*, where the load is greatest, till the magma displaced by the lower surface of the crust is sufficient to float the load. The result will be, firstly an extension of the depression in a direction away from the elevated tract *A*, and secondly a strong tendency to either fracture or flexure of the crust at the junction of *A* and *D*.

As we may take the crust to be infinitely yielding to long-continued stresses, there is no reason why that produced by the lightening of the one area and the loading of the other should not be relieved simply by the sinking of the latter and the rising of the former on either side of a separating plane. But denudation and deposition are not the only forces at work; for, to bring the case into connection with that of the Himalayas, we must suppose compression to be continually at work. This will be relieved partly by an additional elevation of *A*, but also by the compression and consequent elevation of the marginal deposits of *D*, which would not offer the same resistance as the already consolidated beds of *A*. In this way the deposits on the edge of the depression *D* would gradually come to form part of the tract *A*, whose boundary would advance towards *R*, but not to the same extent as the shifting of the outer boundary of the depression towards *R′*.

This must not be regarded as a modification, but rather as an amplification of Mr. Fisher's theory; it is a more detailed investigation of a part of the process which does not lend itself to mathematical treatment. The elevation of the marginal deposits of the depression is of a different nature to that referred to by Mr. Fisher, an elevation which belongs to the period of decadence of the range, and is unaccompanied by disturbance. The Himalayas have only just completed their growth, if they are not still growing, and the elevated marginal deposits with which we have to deal owe their elevation to compression, and belong to the period of growth of the range.

Taking this amplification of the theory, we find that a mountain range which has completed or nearly completed its growth, but not entered on the period of its decadence, should show the following features:—

I. There should be a region continuously exposed to denudation and simultaneously to elevation.

II. Coterminous with this there should be an area where deposition and subsidence are simultaneously taking place.

III. The area of deposition and subsidence should gradually spread outwards from the mountain range.

IV. The region of denudation and elevation should gradually encroach on that of deposition and subsidence.

V. The demarcation between the areas of elevation and of subsidence should be abrupt.

VI. Near the limit the submontane deposits should, during the elevation of the range, be raised with the accompaniment of disturbance.

VII. It is improbable that the system of disturbance would commence simultaneously along its whole length, but rather it would extend longitudinally as well as laterally.

It is only necessary to compare this statement of the deductions arrived at theoretically with the results of observation as given in the first part of the paper, to see how close and complete is their accordance. And in this agreement we find very strong evidence of the truth of the theory.

I have avoided overburdening the text with references; none of the facts are here published for the first time, and but little of the deductions. The ideas and conclusions relative to the history of the Himalayas are well known to those who have worked at it; in a more or less complete form they have been published at different times, but have never before been collected together. The following papers have been made use of, and should be consulted for further details:—

Sir P. T. Cautley. On the Structure of the Sewalik Hills and the Organic Remains found in them. Geol. Trans. second series, vol. v. pp. 267–278 (1840).

H. B. Medlicott. On the Geological Structure and Relations of the Southern Portions of the Himalayan Ranges between the Rivers Ganges and Ravee. Mem. Geol. Surv. Ind. vol. iii. part 2 (1863).

F. Stoliczka. Summary of Geological Observations during a Visit to the Provinces of Rupshu, Karnag, South Ladak, Zanskar, Suroo, and Dras of Western Tibet, in 1865. Mem. Geol. Surv. Ind. vol. v. pp. 337-354 (1866).

A. B. Wynne. Observations on some Features in the Physical Geology of the Outer Himalayan Region of the Upper Punjab. Quart. Journ. Geol. Soc. vol. xxx. pp. 61–80 (1874).

H B. Medlicott. Note on the Sub-Himalayan Series in the Jamu (Jummoo) Hills. Rec. Geol. Surv. Ind vol. ix. pp. 49–57 (1876).

A. B. Wynne. Note on the Tertiary Zone and Underlying Rocks in the North-Western Punjâb. Rec. Geol. Surv. Ind. vol. x. pp. 107–132 (1877).

——— Notes on the Physical Geology of the Punjab. Quart. Journ. Geol. Soc. vol. xxxiv. pp 347-376 (1878).

H. B. Medlicott. Manual of the Geology of India. Cap. 22. 23, 25. 26, 27 (1879).

W. Theobald. The Siwalik Group in the Sub-Himalayan Region. Rec. Geol. Surv. Ind. vol. xiv. pp. 66-175 (1881).

H. B. Medlicott. The Nahan-Siwalik Unconformity in the N. W. Himalayas. Rec. Geol. Surv. Ind. vol. xiv. pp. 169–174 (1881).

R. Lydekker. Geology of the Kashmir and Chamba Territories, and the British District of Khagan. Mem. Geol. Surv. Ind. vol. xxii. (1883).

R. D. Oldham. Note on the Geology of the Gangasulan Pargana of British Garhwal. Rec. Geol. Surv. Ind. vol. xvii. pp. 161–167 (1884).

——— Memorandum on the Probability of Obtaining Water by Means of Artesian Wells in the Plains of Upper India. Rec. Geol. Surv. Ind. vol. xviii. pp. 110-112 (1885).

C. S. Middlemiss. Physical Geology of the Sub-Himalaya of Garhwâl and Kumaun. Mem. Geol. Surv. Ind. vol. xxiv. part 2 (1890).

NOTICES OF MEMOIRS.

I.—Prof. W. Dames on a Swedish Cretaceous Bird.

"Ueber Vogelreste aus dem Saltholmskalk von Limhamn bei Malmö." By W. Dames. Bihang till k. Svenska Vet.-Akad. Handl., vol. xvi. pt. iv. No. 1, with plate (1890).

IN this paper Professor Dames discusses associated right humerus, coracoid, and scapula, apparently of a bird, obtained by Professor Lundgren from the Upper Senonian of Southern Sweden. In the course of his introductory remarks he alludes to the possible occurrence of a gadoid fish in the same formation—the determination being apparently based upon the original example of *Dercetis limhamnensis* of Davis. A detailed description of the bird-bones follows, and the provisional name of *Scaniornis Lundgreni* is proposed for the genus and species they represent. All known carinate birds from the American and European Cretaceous and Tertiaries are successively reviewed in comparison; and a reference to recent skeletons suggests that the new extinct Swedish type is a primitive wader. A. S. W.

II.—The Geology of the Long Mountain, on the Welsh Borders. By W. W. Watts, M.A., F.G.S.[1]

THE author described the Silurian succession in a part of West Shropshire and East Montgomeryshire.

1. May Hill grit, sometimes conglomeratic, containing one richly fossiliferous band of limestone at Cefn, Buttington, This is traced from Cefn to the north end of the Breidden Hills, where it appears to thin out. It rests unconformably on various members of the Bala group, and at Cefn a small dyke of diabase is intruded along the junction line.

2. Purple and green shales with very rare fossils, chiefly Entomostraca and small Brachiopods.

3. Wenlock mudstones, earthy in the lower part, and more calcareous above, containing *Cyrtograptus Linnarssoni*, *Monograptus Flemingii*, *M. dubius*, and *M. serra*. These beds appear to represent the upper part of the Wenlock shale and the Wenlock limestone.

4. Thin muddy shales with rare flaggy ribs, containing *Monograptus colonus*, *M. Nilssoni*, and *Cardiola interrupta*; these are the equivalent of the Lower Ludlow beds.

5. Hard thick flags, with occasional shales. *Monograptus Leintwardinensis*, *M. Salweyi*, *M. Roemeri*, the equivalent of the Aymestry limestone.

6. Thin fissile shales almost barren, but with *Cardiola*. These occupy the place of the Upper Ludlow Rocks. Above these beds comes an outlier of the Passage-beds with *Lingula* and Entomostraca.

The structure of the range is a large syncline with a steep dip on the north-west side, but this is complicated by several dip- and strike-faults and one or two small synclines.

The author acknowledged the great help rendered by Professor Lapworth in determining the Graptolites.

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[1] Abstract of a paper read at the British Association for the Advancement of Science; Leeds, September, 1890; Section (C) Geology.

REVIEWS.

I.—North American Crinoidology.

S. A. Miller.—Structure, Classification, and Arrangement of American Palæozoic Crinoids into Families. Amer. Geol. Vol. vi. No. 5, pp. 275–286, and No. 6, pp. 340–357. Minneapolis, Nov. Dec. 1890.

THAT erudite and enthusiastic writer Mr. Samuel A. Miller of Cincinnati, already famous through his "North American Geology and Palæontology," described by Prof. John Collett as "the most valuable and learned work on Geology and Palæontology ever published," again compels the attention of the scientific world by the elaborate article before us.

Mr. Miller has an extensive and peculiar acquaintance with Crinoids, *i.e.* with those from the Palæozoic rocks of N. America, and has proposed a large number of generic and specific names, some of which will probably stand. What more is needed? Indeed, Mr. Miller himself ridicules P. Herbert Carpenter for supposing that a knowledge of recent forms is of any advantage to the student of fossils. Besides this, Mr. Miller's specific names are never spelled with a capital letter,[1] and they can all be translated by the aid of Andrews' Latin Lexicon. But, for all his learning, Mr. Miller is not proud; he modestly writes as though he could read no language except his own and English. Mr. Miller has too that rare merit in a scientific man—consistency: he never (or hardly ever) changes his opinion, and consequently has earned the right to abuse Wachsmuth for changing his with the progress of knowledge. At the same time it must not be supposed that the classification now put forward by Mr. Miller is the same as that adopted in his "North American Geology." He is careful to explain that it was not then his object "to write an original treatise on any one branch." We are surprised, for that classification struck us as one of the most original we had ever seen.

Discarding the puerile speculations of recent writers as wholly unsupported by fact, Mr. Miller reverts to a classification according to superficial similarities of structure, a method which, with the advantage of simplicity, combines the sanction of antiquity. He, at least, will not follow the vagaries of those who consider a certain character of family value in one place and of barely specific importance in another.

Mr. Miller cannot away with your Morphologist; hence he has never accepted the view that the median circlet of plates in the cup of a dicyclic Crinoid is homologous with the proximal circlet in a monocyclic Crinoid. For him the "basal" plates are always those next the stem; to these the animal was, he states, attached by ligament: *hence* these plates are "the most important in classification of any of the plates in the calyx." The difficulties presented by the numerous pseudo-monocyclic forms do not trouble Mr. Miller, for he does not undertake to deal with Crinoids other than Palæozoic, and, as for these, he boldly asserts that "'rudimentary underbasals' could never have had an existence in any of them." "The number of basals and the shape of the basal disk are of the first importance" in classification; for, as Mr. Miller points out, the number gradually decreases in geological time, and of course no sound thinker could imagine that later forms arise from earlier by descent with modification.

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[1] Except when a patriotic printer insists on a large A for "Americanus."

"The only known function of the subradials is to increase the capacity of the visceral cavity, ... in some genera they cover half the calyx, ... in all cases they materially affect the form and structure, ... where . . . . large they were supported by ligaments . . . . or by denticulated edges . . . . Therefore [how subtle is this logic!]—no family should include genera having subradials and those in which they do not exist."

"The next family character will be found in the presence or absence of regular interradial plates," while the last lies in the structure of the posterior interradius.

"The structure of the arms," Mr. Miller thinks, "is never of family importance, and above the brachials never of generic importance though always of specific value." As we are not informed what sense Mr. Miller chooses to apply to the term "brachials," we can offer no opinion on this point.

We have not space to give a synopsis of Mr. Miller's classification, but a few of the most noteworthy changes may be quoted for the delight of those who appreciate common-sense. Thus:—the Symbathocrinidæ are ranged alongside the Calceocrinidæ: the difficulty of separating species of *Forbesocrinus* from those of *Ichthyocrinus* can exist no longer now that the two genera are placed not only in different families but in separate groups; while matters are still more simplified by the approximation of *Ampheristocrinus* and *Closterocrinus* to the "Ichthycrinoidæ." Again, forms hitherto foolishly placed so far apart as *Eucalyptocrinus*, *Mariacrinus*, and *Xenocrinus*, are now to be found in the same group of families. In the Cyathocrinidæ are gathered *Bursacrinus*, *Carabocrinus*, *Graphiocrinus* and others, even including *Cyathocrinus*.

But for the rest of this exciting and amusing article we must refer our readers to the Christmas number of the "American Geologist" for 1890. And we would especially recommend its perusal to our younger readers; for there they will find exemplified a lucidity of exposition, an accuracy of argument, and a courtesy in debate that remind one of the Society upon the Stanislaus, though from the Report of that body even Mr. Miller might profit. The journals in which we publish may be "conduits of ignorance and conceit." We are "illiterate," "reckless of symmetry," "shallow pretenders" "venting stupid hypotheses"; in our "unenlightened affectation" we make our "usually poor English more incomprehensible" by quoting "snatches from German authors," we give full references, and we never have more than 30 misprints in 18 pages (Mr. Miller rises to 40). Yes! we are all this; we do all this: and yet, "overgrown" with "ignorance, assumption, and conceit" as we are, we humbly confess that on this side the Atlantic we have never produced anything that would, for sweet reasonableness and smoothness of persuasion, stand a moment's comparison with the gentlemanly polemics of Mr. S. A. Miller, Cincinnati, O.

II.—MR. JAMES W. DAVIS ON SCANDINAVIAN CRETACEOUS FISHES.

"ON THE FOSSIL FISH OF THE CRETACEOUS FORMATIONS OF SCANDINAVIA." By JAMES W. DAVIS, F.G.S., F.L.S. Trans. Roy. Dublin Soc. [2] vol. iv. pp. 363–434, pls. xxxviii.–xlvi. (November, 1890.)

OF all extinct fish-faunas, that of the Cretaceous period is gradually becoming the best known, on account of the abundance in which remains are discovered in every part of the world. A large proportion of these remains are too imperfect for precise determination; but they suffice, at least, to make known the geographical distribution of the principal types, and the fossils of a few areas—*e.g.* Britain, Westphalia, Syria, Brazil, and Western North America—are so admirably preserved as to form definitely determined standards for comparison. Mr. Davis' new Memoir is the latest contribution to the subject, and comprises a beautifully illustrated account of the Upper Cretaceous Fishes of Southern Sweden, with its adjacent islands, and the neighbouring shore of Denmark.

Apart from incidental references, the Cretaceous fish-fauna of this northern region has hitherto remained quite unknown, and ichthyologists are much indebted to the Curators and Professors of the Scandinavian Museums and Universities for entrusting all their collections to a specialist for elucidation. Mr. Davis' researches are based upon materials from the Swedish State Museum, the Swedish Geological Survey, and the Universities of Lund and Copenhagen. On the whole, the specimens are of a very fragmentary character, but most of them are at least generically determinable, and many appear to be specifically identical with well-known forms from Britain and other areas. The great interest of the collection consists in the fact, that while it is in part derived from truly Senonian horizons, the majority of the specimens were obtained from the Danian series. Some of the species, therefore, are of a decidedly Tertiary character. Prof. Bernard Lundgren supplies important stratigraphical information which is tabulated at the end of the memoir; and from this table may be perceived at a glance the geographical and geological range of the thirty-four species described.

Most of the fossils under discussion, as might naturally be expected, are Elasmobranch teeth; and the author's introductory remarks deal chiefly with the classification of the Cretaceous Lamnidæ. While adopting to a large extent the arrangement formulated in the British Museum Catalogue of Fossil Fishes, Mr. Davis prefers to revert to the Agassizian conception of *Otodus* and *Odontaspis*, and is uncertain whether any ichthyologist hitherto has philosophically determined the limits of *Carcharodon*. The principal difference between the Catalogue just cited and the memoir now before us consists in the fact that the former attempts to treat the fossils as remains of genera and species of Elasmobranchs, while the latter deals with them as so many "forms" of detached teeth, which can be distinguished and thus variously named.

Among features of special interest relating to the Elasmobranchs, may be noted the occurrence in the Danian of typical examples of *Ptychodus decurrens*, *P. mammillaris*, *Notidanus microdon*, *Oxyrhina Mantelli*, and the so-called *Otodus appendiculatus*—all well-known Cretaceous forms. With these are found an undetermined species of *Myliobatis*, and some apparently new forms of *Scapanorhynchus*, *Oxyrhina*, *Lamna*, and *Scyllium*, besides a large imperfect tooth of *Notidanus* indistinguishable from *N. dentatus* of the New Zealand Greensand. An *Odontaspis*, both from the Senonian and Danian, is also identified with a New Zealand species (*O. acuta*); but we venture to think that this is the well-known European Danian species, *O. Bronni*, to which the author makes no reference. The so-called *Odontaspis acutissima* and *O. faxensis* are undoubtedly teeth of *Synechodus*, as proved by the form of the root; and, as remarked by the author himself, there is much doubt about the generic determination of the beautiful new teeth described as *Oxyrhina Lundgreni*. Though often recorded from the Cretaceous, it is still very uncertain whether the typically Tertiary species, *Odontaspis elegans*, ranges so far downwards, and the smooth teeth assigned to this form by Mr. Davis are far from conforming to Agassiz' original definition; but the occurrence of a tooth indistinguishable from the so-called *Otodus obliquus* in the Upper Senonian of Rugaard is a fact of great interest. A portion of a tooth of *Carcharodon* from the Danian of Faxoe is even identical in character with the teeth of the existing *C. Rondeleti*, but this scarcely suffices for certain determination.

Some Chimæroid teeth from the Senonian appear to pertain to the widely distributed species, first described from Switzerland as *Ischyodus Thurmanni* and afterwards re-described in Britain under the name of *Ischyodus brevirostris*. *Edaphodon*, however, remains unknown, and there are no traces of *Elasmodus*.

Of Pycnodonts, there occur only teeth which are referred with much probability to *Cœlodus subclavatus*; and of Teleosteans there is only evidence of about six genera. Of the latter, the finest specimens pertain to *Hoplopteryx* and to a new deep-bodied physoclystous fish, which receives the name of *Bathysoma Lutkeni*. *Berycopsis* and *Dercetis* also seem to be represented; another fossil is provisionally named *Clupea Lundgreni*; and some specifically indeterminable teeth of *Enchodus* are recorded. With regard to *Enchodus* we would remark that the author does not seem to have studied the most recent discoveries, and thus assigns the genus still to the family Trichiuridæ. Here is also placed *Bathysoma*, though a critic noting the fact will perhaps be answered again in the words of the foot-note on p. 369, that the arrangement is due to "the omission of a line." *Bathysoma*, indeed, is one of the most remarkable Cretaceous fishes hitherto discovered, and we only regret that a more satisfactory determination of its affinities has not been attained. So far as the terms of the "generic definition" are concerned, the name will apply equally well to a sole or a sun-fish; but the fine figures and detailed description of the fossils help to compensate for the insufficiency of the diagnosis.

The memoir as a whole makes an important advance in our knowledge of the Upper Cretaceous Fishes of Western Europe, and ichthyologists are much indebted to the author for providing so many new facts that will assist in future generalizations.

A. S. W.

III.—Dr. E. Fabrini on Machærodus.

Machærodus (Megantherеon) del Valdarno Superiore, Memoria del Dott. Emilio Fabrini. (Boll. R. Com. Geol. 1890, Nos. 3–6, pp. 43, pls. 3.)

THE present Memoir is another of the series intended to illustrate the extinct Mammalian fauna of Italy, reference to which has already been made in our issue of last month.

The author describes in full detail, with excellent illustrations, all the more important remains of Sabre-toothed Tigers (*Machærodus*) from the Pliocene of the Val d'Arno preserved in the Italian Museums. He concludes that two species have hitherto been confused together under the name of *M. cultridens*. In that species the upper canine teeth of the male are long and narrow, and have no serrations on their trenchant edges; and it is believed that the smaller skulls and jaws which have been regarded as representing a distinct species—*M. megantherеon*—are really referable to females of *M. cultridens*. A second new species designated *M. crenatidens* is distinguished by the shorter and wider canine teeth of the males, in which both the front and hind edges are strongly serrated. In accordance with the contour of the canine the hollow in the flange of the lower jaw, against which they are applied, is likewise unusual. It is considered that the lower jaw from the Norfolk Forest-bed, described by the late Mr. Backhouse in the Geological Society's Journal, is referable to this form, whereby a new species is added to the British Fauna.

A second new species, which it is proposed to designate *M. nestianus*, is characterized by the upper canine teeth carrying serrations only on their hinder edges; and likewise by the long gap separating the third and fourth premolars in the lower jaws. It is suggested that it may be advisable to regard this species as the type of a new genus, in which case the name *Homotherium* might be adopted.

R. L.

IV.—Sur la nature Végétale de l'Aachenosaurus multidens, G. Smets. Par Dr. Maurice Hovelacque. (Mem. Soc. Belge de Géol. iv. (1890) p. 59 *et seq.*)

THE "wooden Dinosaur"—as the so-called *Aachenosaurus multidens* has not inaptly been termed on this side of the Channel—has at length received its *coup de grâce* at the hands of the author of this memoir. The vegetable nature of the fossil could not possibly be disputed by any one who examines the descriptions and figures in the text with the accompanying plate; or who, like the writer of this notice, has had the privilege of seeing sections of the "bones" under the microscope. The two fragments examined by Dr. Hovelacque, viz. the so-called *épine dermique* and *mâchoire,* he shows to belong to two different families of plants, and they now receive the names of *Aachenoxylon* and *Nicolia Moresneti* respectively. G. F. H.

V.—La Faune Tertiaire Marine de Carry, de Sausset et de Couronne (près Marseille). Facies des Étages Tertiare dans la Basse-Provence. Par M. Paul Gourret. (Mem. Soc. Belge de Géol, iv. (1890) pp. 73–143, with four plates.)

THE author commences by giving a general outline of the Tertiary beds of Basse-Provence, showing that the Eocene, Oligocene, Miocene and Pliocene are each represented in that district. In this memoir he gives a few palæontological details fixing the horizons of the several beds and roughly correlating them with the Tertiary strata of adjacent areas.

The second part enumerates the species found at the three places mentioned in the title of the memoir, and under the heading of each of these species are placed the names (where necessary) of what the author considers to be synonyms, together with a brief account of its geologic and geographic distribution. with occasional critical remarks. This is the most important section of the paper, and it is put forward as a revision of the whole fauna and as the result of much careful research. In all, 301 species of fossils are recorded, which are distributed as follows: — Pisces 8, Crustacea 5, Mollusca 247, (Gasteropoda 157, Pelecypoda 90), Polyzoa 6, Brachiopoda 3, Echinodermata 13, Cœlenterata 19. The Fish belong to the genera *Lamna, Myliobates, Oxyrhina* and *Sphærodus* (*sic*); whilst the Crustacea are mainly *Balani.* The Mollusca naturally claim a large share of attention, and it may be remarked that in dealing with them, the author does not adhere to certain well-known and generally accepted rules of nomenclature, which is much to be regretted. For example, when the generic appellation of a species is changed, he inserts the name of the individual who made the alteration after the specific, instead of that of the original describer of the species. The science of Malacology has made great strides during the past ten years, but this fact has not been sufficiently recognized in the memoir now under review. It would be tedious to point out all the shortcomings in this respect, but we may mention *Pyrula melongena,* Bast., which should be *Melongena cornuta,* Ag.; *Pyrula bulbus,* Desh. = *Sycum bulbus,* Sol.; *Buccinum baccatum,* Bast. = *Cyllenina baccata,* Bast.; *Buccinum reticulatum,* Linn. = *Nassa reticulata,* Linn.; *Voluta rarispina,* Lam. = *Volutilithes rarispinus,* Lam.; *Ancillaria* = *Ancilla*; *Chenopus* = *Aporrhais.* Again, no attempt is made to classify the larger groups — the heterogeneous assemblage of forms which were included under such genera as *Pleurotoma*, *Fusus*, *Buccinum*, *Bulla*, *Cerithium*, *Natica*, *Venus*, etc., during the first decades of the century, are still classified as they then were, in the lists of the fossils from Marseilles before us. The synonyms given are in many instances inaccurate also. It may be said that the second section of the memoir is useful as giving an idea of the richness and general character of the fauna of the Upper Tertiary beds of the localities mentioned, and at any rate it is something to have a complete list of the known species, even although some may be wrongly determined; but the whole requires very careful revision before it can be of any material value to the systematist.

The third section gives the distribution in detail of the fossils found, showing their vertical and horizontal ranges, and this is unquestionably the most useful portion of the work. The four plates, which are beautifully executed, re-figure certain characteristic Mollusca and depict five new species which are described in the text.

G. F. H.

VI.—CATALOGUE OF MINERALS FOR SALE. By GEO. L. ENGLISH AND Co. 8vo. Philadelphia and New York, 1890. Price 25 cents.

THIS book is no mere dealer's catalogue, but contains a large amount of useful information, concisely arranged for ready reference. A brief résumé of the more recently described minerals is given, followed by a classification and list of all known minerals arranged according to their chemical composition. In this list the crystallographic system and the general formulæ are mentioned, and the whole is rendered more complete by a good index at the end of the volume. Several figures are given, including eight fine crystals of Beryllonite from Stoneham, Maine.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—December 17, 1890.—W. H. Hudleston, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read:

1. "On Nepheline Rocks in Brazil.—II. The Tingua Mass." By O. A. Derby, Esq., F.G.S.

In a former paper the general distribution of the nepheline rocks, so far as known, was given with a particular description of a single one, the Serra de Pocos de Caldas. The present paper treats of a second mass, the Serra de Tingua, a high peak of the Serra do Mar, some forty miles from Rio de Janeiro.

The peak is essentially a mass of foyaite rising to an elevation of 1600 metres, on the crest and close to the extremity of a narrow gneiss ridge of a very uniform elevation of about 800 metres. As seen from a distance, the conical outline and a crater-like valley on one side are very suggestive of volcanic topography. In the structure of the mass both massive and fragmental eruptives are found, the former greatly predominating.

The predominant rock is a coarse-grained foyaite which is found everywhere in loose blocks about the margins of the mass, but not extending beyond it. In the numerous cuttings in the immediate vicinity, dykes of phonolite and basic eruptives (augitite) are exceedingly abundant, foyaite never appearing in a dyke form. There is, however, abundant evidence that foyaite and phonolite are but different phases of the same magma.

Aside from the dyke phonolites, true effusive phonolites associated with fragmental eruptives (tuffa) were found high up in the crater-like valley, proving that the mass was a volcanic centre in the most restricted sense of the word.

This conclusion affords an explanation of some of the peculiarities of the foyaite, which has many characteristics of effusive eruptives mingled with those of the deep-seated ones (*Teifengesteine*). These have, aside from the porphyritic structure, a ***schlieren*** structure revealed by a peculiar fluted weathering (illustrated by a photograph) and the presence of pseudo-crystals in the form of leucite.

Statigraphically the Tingua foyaites lie in sheet-like masses like lava-flows, extending from the higher to the lower portions of the mountain, the underlying gneiss being revealed at nearly all levels, wherever the mass has been scored by streams. The general fragmentary character of the rock seems to be due to the undermining of these sheets.

Specimens and photographs illustrating the peculiar pseudo-crystals in the form of leucite that occur in both the foyaites and phonolites of Tingua (although no leucite has been detected in the rock) were exhibited and discussed.

2. "The Variolitic Diabase of the Fichtelgebirge." By J. Walter Gregory, F.G.S., of the British Museum (Natural History).

The author has examined the variolitic diabases in the neighbourhood of Berneck, and adduces evidence of their having been intruded into the Devonian rocks before the latter were affected by the great earth-movements which have folded the Palæozoic rocks of the district. He finds that the variolitic structure occurs in two different arrangements: (*a*) on the surfaces of spheroidal masses of compact diabase, which are comparable with those of Mt. Génèvre; (*b*) as a true contact-product on the selvage of the diabase, the latter being comparatively rare, and the varioles less perfectly developed.

He gives proofs that the varioles are true spherulites, and not fragments of Devonian rocks, as supposed by von Gümbel. He argues that though they are the product of rapid cooling, too sudden a solidification of the diabase may prevent their formation, and that for a similar reason the amygdaloidal is less variolitic than the compact diabase, the loss of the water that occupied the vesicles having diminished the fluidity of the rock. Finally, he maintains that the "pseudo-crystallites" are rifts and fissures due to contraction, and that the remarkable optical properties described by Michel-Lévy are due to the filling-up of cracks by felspathic matter deposited in optical continuity with the crystalline fibres on each side.

II.—January, 7, 1891.—A. Geikie, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the North-west Region of Charnwood Forest, with other Notes." By the Rev. E. Hill, M.A., F.G.S., and Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The paper contains the results of a re-examination of the North-west Region, when the authors had the advantage of using the Six-inch Ordnance-map, published since the completion of their former work. In this they had expressed the opinion that the rock of Peldar Tor and that of High Sharpley were somewhat altered pyroclastics, being much influenced by the non-igneous origin asserted for the "porphyroids" of the Ardennes. But in 1882 one of them had visited this region, and was then convinced that the porphyroids, which closely resembled the rock at Sharpley, were felstones which had been rendered schistose by subsequent pressure. The result of their subsequent work in Charnwood has convinced the authors that the rocks of Sharpley and of Peldar Tor are in the main of a like origin and history. The mass of Bardon Hill, where the quarries have been much enlarged, has also been studied, and some details in the section formerly published have been corrected. The schistose bands, on which the authors relied as marking horizons for stratigraphical purposes, prove to be zones of exceptional crush. The occurrence of a rock exactly resembling that of Peldar Tor is fully established. It is extremely difficult to decide upon the true nature of the rocks which are chiefly worked in the pit, but the authors remain of opinion that for most of them a pyroclastic origin is the more probable.

Some notes are added upon the relations of the holocrystalline igneous and the sedimentary rocks of the Forest, upon the Blackbrook group, and upon the fragments and pebbles in certain of the coarser ashy deposits. Some remarks are made upon the glacial phenomena exhibited in the Forest-region; these indicate that this cannot have been overridden by a great northern ice-sheet and it does not afford the usual signs of the action of local glaciers. At the same time it has been a centre of dispersion for erratics, especially towards the south and south-west, these being found sometimes more than twenty miles away. Hence, in the opinion of the authors, the erratics have been distributed by floating-ice during an epoch of general submergence. Some minor "Corrigenda" in the earlier papers are noted, with certain changes in the names of localities, bringing them into harmony with the Six-inch map.

2. "Note on a Contact-Structure in the Syenite of Bradgate Park." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S.

The author described a specimen, obtained at Bradgate Park, showing a junction of the syenite and slaty rock of Charnwood. The latter rock is very slightly altered; the former exhibits a number of grains of felspar and quartz set in a matrix which has now a "trachytic," now a devitrified structure. He traced the former into the "micrographic" structure observed generally in these syenites, and discussed its significance. His study of these structures in this and many other instances led him to infer that they generally indicated that the rock, at a late stage, had consisted of a mixture of previously formed crystalline grains and a viscous magma, that the temperature of the mass has been comparatively low, that it had cooled rather gradually, and that the condition of the magma—*i.e.* one of very imperfect fluidity—had not permitted of free molecular movements among its constituents. Thus this structure, together with certain others mentioned, might be regarded as indicative of "crystallization under constraint."

3. "On the Unconformities between the Rock-Systems underlying the Cambrian Quartzite in Shropshire." By Charles Callaway, D.Sc., F.G.S.

I. *Review of the Evidence for the respective Ages of the Uriconian and Malvernian Rocks.*

The author criticizes the conclusions arrived at by Prof. Blake (Q.J.G.S. 1890, p. 386), and adduces evidence to show:—

(1) That the felsites regarded by himself as Archæan have *not* been shown to be intrusive in Longmynd Rocks.

(2) That it has not been proved that the Longmynd Series is divisible into two groups, separated by an unconformity; and that, therefore, the evidence from included fragments remains unaffected.

(3) That the conglomerates and grits associated with the Uriconian are an integral part of that system, and are not of Cambrian age; and that the granitic and metamorphic land-masses from which so many of the fragments in the conglomerates are derived are consequently of pre-Uriconian age.

(4) That the granitic rocks of Shropshire are not intrusive in the Uriconian.

II. *The Relation between the Uriconian and the Longmyndian.*

Pending the publication of Prof. Lapworth's researches upon the fauna of the Hollybush Sandstone, the author regards it as hardly wise to assign positively a pre-Cambrian age to the Longmyndian system.

In favour of an actual break between the Uriconian and Longmyndian rocks, he gives details showing the general discordance of strike between the two groups; the locally concordant strikes are seen along a line of fault. Furthermore, as the junction between the two groups is faulted, this, whilst of course not proving an unconformity, renders incredible the hypothesis of conformity and igneous intrusion along the line of junction. Again, the conditions of deposit were different: the Uriconian is essentially a volcanic formation, whilst the Longmyndian rocks are characterized by their even sedimentation, and the author maintains that such a change of conditions must indicate a break in time, though the unconformity need not necessarily be very great.

Lastly, the occurrence of fragments of Malvernian granites and schists (formed at great depths) in the Uriconian Conglomerates indicates the existence of an unconformity between the holocrystalline and volcanic systems.

CORRESPONDENCE.

"STEM-OSSICLES" OF CRINOIDEA, IN THE LEPTÆNA-KALK (UPPER ORDOVICIAN) DALECARLIA, SWEDEN.

SIR,—A reviewer (F.A.B.) of my notice "Om förekomsten af en Caryocrinus i Sverige" has said in the GEOLOGICAL MAGAZINE, December, 1890, p. 570: "The rock is filled with stem-ossicles which Dr. Holm, after the curious custom of collectors, thinks it necessary to ascribe to Crinoidea." What I regard as stems of at least two species of Crinoids, the reviewer says are stems of Cystidea without his having seen a single one of them. But the real fact is that these stems in consequence of their structure must have belonged to Crinoids. One of the supposed species has left fragments of stems 45 mm. in length by 16 mm. in breadth. These show the starting-points where strong cirrhi originated, and as far as known cirrhi have not been found in the Cystidea. Thick and expanded rootlets of Crinoids are also not rare. To this must be added, that all known Cystidea from this same locality, with the exception of *Caryocrinus cfr ornatus*, Say, are devoid of a stem. According to Angelin the genera *Sphæronis*, *Eucystis* and *Caryocystis* are sessile, having the basis of the perisome itself directly affixed to foreign bodies without the mediation of a stem, and several of the specimens observed by me of *Sphæronis oblonga*, Ang., and *Eucystis sp.*, either show the surface by which they were attached, or are even yet affixed to Bryozoans or other marine Silurian fossils. Of *Caryocystis* I have seen only a single specimen, and this does not show the basis of the perisome clearly. A species of *Eucystis* is numerically by far the most predominant form. This is the cause why I have, with full intention, referred the stems to Crinoids.

STOCKHOLM,
15th January, 1891.

GERHARD HOLM.

THE DENUDATION AND ELEVATION OF THE WEALD.

SIR,—In the December Number of the GEOLOGICAL MAGAZINE, Dr. Irving states that in my sketch in the September Number I reproduced partly some arguments which he put before the Geological Society in June (May 21st, 1890?), and published in the September Number of the GEOLOGICAL MAGAZINE. I applied to Dr. Irving for particulars, and he informed me "that the argument from the raised beaches and the reference to the crag at Lenham were the points referred to."

Now, Sir, as to the argument from the raised beaches, mine is quite a different argument from that used by Dr. Irving. I use it in the course of a criticism on Sir A. Ramsay's diagram (Geol. and Geog. of Gt. Brit. 1878, p. 343, fig. 73) as a local and recent example of elevation turning a horizontal beach-line into a curve. Dr. Irving omits the fall to the west, and uses it to prove western elevation of the Wealden area.

As to the Lenham beds, I have the right to refer to them without obtaining leave.

I do not lay claim to any great originality for my little sketch, but, in fact, I did not derive my ideas from Dr. Irving's paper.

3, Pump Court, Temple, E.C. Horace W. Monckton.

REPLY TO MR. A. SOMERVAIL.

Sir,—I owe an apology to Mr. Somervail for plucking a leaf from his coronet of laurels. It is the simple truth that the paper which he cites had not in any way impressed itself on my mind, and thus (as the index for the last volume was not then published) escaped recollection. While making this atonement, I will take the opportunity of explaining to him why I use that plainness of speech to which he evidently objects. If he is right in his principal hypothesis about the rocks of the Lizard, I am so hopelessly wrong that I must begin my petrological studies *de novo*. The one or the other of us, so to say, is ignorant of the very grammar of the language. Now, as it happens, I have given, for nearly twenty years, more attention to petrology than to any other branch of geology; twice or thrice every year I have visited districts which were known to be instructive, making often long journeys in order to study some critical question. I have examined many of the most interesting localities on the Continent of Europe, a few also in Canada. I have formed a very large collection of rock specimens and microscopic slides, to the study of which I have devoted such leisure as I can command. Now in Mr. Somervail's writings no evidence appears of either wide experience or knowledge of the microscope, both of which are necessary for theorizing on difficult problems in petrology; indeed, of the latter, not so long since, he admitted his ignorance. Of course I know that many of these problems are yet unsolved; I make no claim to infallibility; I am well aware that notwithstanding all my pains I have not escaped the fate of workers in a progressive science, and have to modify or even abandon conclusions which at one time seemed most accordant with facts, but some of Mr. Somervail's hypotheses appear to me irreconcilable with facts and inductions which, not only I, but also petrologists of greater repute, accept almost as axioms. To me he appears to occupy the position in which I should have placed myself had I signalized my entrance in the "fifth form" at school by publishing "adversaria" on a trilogy of Æschylus.

T. G. Bonney.

DYNAMO-METAMORPHISM.

Sir,—M. Spring's valuable experiments have had a very stimulating effect on many minds; so much so that his experiments are sometimes quoted in proof of positions very much in advance of those taken by M. Spring himself. Thus Mr. Harker in his letter on the subject of dynamo-metamorphism in your last issue, after remarking that "the practical verification" of "the *direct* correlation of mechanical and chemical energy" "rests on such experiments as those of Cailletet, Pfaff and Spring," refers to one of the experiments of the latter in the course of which sulphur and copper filings subjected to a pressure of 5000 atmospheres were converted into crystallized copper sulphide. Mr. Harker comments on this as follows:—"So much of the mechanically-developed energy as takes the form of heat is carefully removed; but chemical combination still takes place. It follows that the energy absorbed in this combination comes directly from the mechanical work done, without the intervention of heat."

I have no desire to interpose in the controversy between Mr. Harker and Dr. Irving, but, without doing this, I may point out that the explanation offered by Mr. Harker does not appear to be in accord with that offered by M. Spring himself.

In the American Journ. Science, xxxvi. (1888) pp. 286–289, Spring remarks regarding his "researches on the compression of powders," "To my mind pressure was not an active agent in the matter; but only the means to the end, and I looked for the effects to contact alone. . . . In another place [Bull. Soc. Chemique, 1884], I said with regard to chemical action produced by my experiments—'one must not lose sight of the fact that pressure is not a chemical agent to the same extent as heat or electricity.' But as I have always thought that *contact* was brought about by compression, I have often, for the sake of brevity, spoken of '*welding* due to pressure,' instead of always saying welding due to contact produced by compression. I now see that I was unwise in thus wishing to economise my time. Besides, as conclusive proof that it is always to contact that I assigned welding phenomena, chemical reactions, and also in part the diffusion of solids, there is the fact that I deemed it necessary to operate *in vacuo*, on account of the failures in preliminary experiments made under the ordinary conditions;" and M. Spring goes on to explain that when he did not operate *in vacuo* the presence of air between the particles hindered intimate *contact* between them and thus prevented chemical action, pressure notwithstanding.

In a previous communication to the American Journ. Science (vol. xxxv. 1888, p. 78) Mr. Spring wrote: "Since then [1880] new experiments, still in part unpublished, have made me recognize the importance of the part that a certain degree of temperature plays in these phenomena, so that for the solid state, as well as for the gaseous one, a *critical temperature* would be remarked, above or below which the changes of simple pressure would be no longer possible."

Spring, therefore, in the conclusions arrived at as recently as the close of 1888, attributes the chemical action set up in his experiments to *contact* plus a certain degree of *temperature*. Pressure is merely the matrimonial agent, so to speak, that brings the highly susceptible particles together; but it is to *contact* plus *heat* that, according to Spring, the chemical action is due.

C. A. McMahon.

20, Nevern Square, 12*th Jan.* 1891.

FUNNEL-HOLES ON LEBANON.

Sir,—The nmerous funnel-holes upon the tops of the Lebanon and Anti-Lebanon Mountains afford striking examples of the power of solution and chemical disintegration unsupplemented by the action of torrents. My attention was directed to these holes last spring by Dr. Wm. T. Van Dyck, of Beirût, who also suggested a theory for their formation. A summer journey, which took me to the tops of nearly all the mountains of Lebanon and Anti-Lebanon as well as to Mount Hermon and the Anseireh Mountains, gave me an unusually good opportunity to observe these phenomena and enabled me to verify and somewhat amplify the idea suggested by Dr. Van Dyck.

The higher portions of the mountains visited were from 6000 to 10,500 feet above the sea-level. Below the level of 5000 feet their sides are worn by running water into very rough and precipitous gorges. Our attention was quite forcibly called to this feature by the great difficulty of climbing among the lower slopes. Above 6000 feet however the slopes become more rounded and the surface of the ground more smooth, until on the broad summits of some of the highest mountains carriages might safely be driven. This is markedly true of the summit plateau of the most lofty of all, the Ḍuhr-il-Ḳaḍîb, sometimes called the Fem-il-Mezâb. The lower slopes of the mountains in the winter and early spring abound with rushing torrents, but in the long summer these portions are perfectly dry, except in those rare and precious spots where there are springs. Here, consequently, the forces of disintegration are active during the winter and spring, and most of the *detritus* is washed away at once, leaving the rocks rugged and bare.

Different conditions are found in the upper regions. The thawing of the snow is gradual, so that probably the larger portion of the water, instead of running off, sinks into the ground, which on the heights is composed of a thick layer of more or less finely comminuted chips of stone over the solid rocks *in situ*. Even late in the summer we found on the eastern side of every favourably situated ridge or peak a large mass of snow sheltered from the prevailing warm west wind, and melting a little every day from about noon until sunset. At the foot of every such mass of snow was a funnel-shaped hole into which trickled every afternoon a tiny stream of water. We observed also many other such holes from which the snow had gone. The diameters of these across the top ranged from a few feet to one hundred yards, and the sides usually sloped at angles of from 15° to 40° straight to a point at the bottom, making inverted and irregular, but yet complete rather than truncated cones. The western side was usually the steeper. I may add that most of these holes occur in a compact limestone generally considered to belong to the Middle Cretaceous period, and further, that the *strata* can be traced as almost perfectly level for miles along the sides of these summits.

It follows then that the principal agency in the formation of each of these funnel-holes must have been the chemical and solvent action of the water from its own snowdrift, aided to some extent by the mechanical work of the frost. ALFRED ELY DAY.

SYRIAN PROTESTANT COLLEGE, BEIRÛT.

ELEVATION AND SUBSIDENCE DURING THE GLACIAL PERIOD.

SIR,—In reply to the article by A. J. Jukes Browne (GEOLOGICAL MAGAZINE, December, 1890, p. 561), concerning high continental elevation of America with relation to the Glacial period, I may refer to my appendix in Prof. G. F. Wright's "Ice Age in North America," as containing a review of evidences of subsidence in the West Indies, cited in that article, probably contemporaneous with the elevation and glaciation of the northern part of North America. It was pointed out fifteen years ago by Dr. Ricketts (GEOL. MAG. Dec. II. Vol. II. 1875, pp. 573–580) that submergence of the Isthmus of Panama may have been an important element in the causes of the Glacial period; and at about the same time the collection by Dr. G. A. Maack of abundant Pleistocene fossils, "all living up to the present time," in the vicinity of the Panama railroad, and at many localities southward to the Atrato river, ranging in height up to at least 763 feet, while the lowest points of the interoceanic water-shed are less than 300 feet above the sea, gave proof that parts of this isthmus have been thus lately submerged (Reports of Explorations for a Ship Canal, Isthmus of Darien, United States Navy Department, Washington, 1874, pp. 155–176).

Nothing is more surely determined than the record of the Glacial period, as shown by glacial drift and striæ upon North America from the Atlantic to the Pacific, and from southern Illinois to the Arctic Sea, and upon north-western Europe from the British Isles to Germany and Central Russia, and northward across the Scandinavian peninsula. Some causes must have existed to produce the great climatic changes of this period. These causes seem to me to have been probably the great uplifts of the glaciated areas of which Professor Spencer has cited so much evidence, and the contemporaneous depression of the region of the West Indies and Isthmus of Panama, by which a part of the equatorial oceanic current that sweeps northward in the Gulf Stream would be permitted to pass into the Pacific Ocean, withdrawing a large portion of its heat from the North Atlantic area. Correlative northern elevation and southern subsidence, for both of which we have sufficient proof, would contribute almost equally to the climatic changes of the Ice age. This subject, and the probably contemporaneous uplift of a belt of land across the North Atlantic from France and Great Britain to the Færöe Islands, Iceland, and Greenland, as argued by Prof. James Geikie in his "Prehistoric Europe," I have discussed somewhat fully in the American Geologist for December, 1890, and the American Journal of Science for January, 1891, in the endeavour to ascertain the probable causes of the remarkable Quaternary changes of climate. WARREN UPHAM.

SOMERVILLE, MASS., *January 6th*, 1891.

PHYSICAL GEOLOGY OF THE SUB-HIMALAYA.

SIR, — May I be permitted a few remarks in reply to Mr. Medlicott's review of my memoir in this MAGAZINE for October, 1890? I cannot attempt to answer objections of a theoretical nature, or of purely local interest to us in India; but on one or two points where I think Mr. Medlicott has mistaken my words or my meaning I would say a word or two. With regard to the fault at Jirinjala in my horizontal section No. V., which Mr. Medlicott says "seems uncalled for," I must plead that the fault is nevertheless there, as plainly visible in the natural sections exposed as in my drawn section. It is not a fault inserted to meet a theoretical requirement. The firm lines in all my sections indicate facts (when not otherwise stated in the text), whilst the dotted lines alone represent inferential conditions of the rocks. The large scale, four inches to the mile, maps would have fully satisfied Mr. Medlicott on this point had they been procurable. In speaking of, and representing, the main boundary, the Nahan-Siwalik boundary, and others, as faults, I hope I have not "ignored their primary and most interesting character" (see p. 118–123 of my memoir). They are certainly faults *now*—sometimes with miles of throw or thrust (see p. 66); hence to lay them down on the map as natural boundaries, because they originally grew out of such, would be a very grave error. It would be akin to representing the lie of the beds as horizontal, for the reason that they were originally deposited so. In addition it must be remembered that the present faulted boundaries are not absolutely, but only approximately, coincident with the original limits of deposition. In some cases, as at Jirinjala, the original boundary, and the approximately coincident faulted boundary, are both present, and need a separate and distinct method of representation.

The difference between section VI. and section IX. with regard to the position of the Nummulitic and Tal beds on the subjacent rocks, is owing to the thinning out of the Massive Limestone, or to its previous erosion. This is plainly illustrated in the map accompanying my paper on the "Physical Geology of W. British Garhwal" (Records G. S. of I. vol. xx. pt. 1). To state, as Mr. Medlicott has done, that my "facts in favour of an earlier plication of the Himalayan rocks are only quotations of wholesale differences of strikes in that region," is to simply misquote me, as the first words on page 127 of my memoir will make evident.

In criticising Mr. Mellard Reade's theory of mountain-formation, as applied to the Himalaya, I did not impute blunders to Babbage and Herschel "in the elements of science." What I did was to show that Mr. Reade's application of the Babbage-Herschel theory in the case of *great sedimentation* was unsound. Again, though the Babbage-Herschel principle may involve the idea of a "fluid substratum," as Mr. Fisher's theory does, the same is not true of Mr. Reade's theory, with which I was concerned. The latter expressly assumes the earth to be solid.

C. S. MIDDLEMISS.

ABBOTTABAD, PANJAB, 12*th December*, 1890.

DYNAMIC METAMORPHISM.

SIR,—All that is contained in the letters of Mr. Fisher and Mr. Harker in the January Number of the GEOLOGICAL MAGAZINE can be, I think, fully and completely answered, though not within the space of a short letter. All that Mr. Fisher's high "authority" has put forward is very well known to students of chemistry, and was before my own mind, when I wrote my previous letter. I will only here repeat my former statement (attaching now to the phrase the meaning I did then) that "chemical combination must generate heat."

WELLINGTON COLLEGE, BERKS, A. IRVING.
25th Jan. 1890.

MISCELLANEOUS.

PROFESSOR SIR WARINGTON SMYTH'S SUCCESSOR.—The Lord President of the Council has appointed Dr. C. Le Neve Foster, F.G.S., Inspector of Mines under the Home Office, and formerly of the Geological Survey of England and Wales, Professor of Mining in the Royal College of Science, London, with which the Royal School of Mines is incorporated.

THE SAIGA ANTELOPE IN BRITAIN.—An interesting addition to the known British Pleistocene Fauna has recently been made by the discovery of a portion of the skull of the Saiga Antelope (*Saiga tartarica*, Linn. sp.) in the Thames Gravels at Twickenham, near Richmond. The specimen consists of the well-preserved calvarium with both horn-cores, and was obtained from an excavation in Orleans Road, Twickenham, by Dr. J. R. Leeson, F.G.S. It was forwarded to the British Museum for determination, and the interest of the discovery was recognized by Mr. Smith Woodward, who exhibited and described the fossil at the meeting of the Zoological Society on November 4th, 1890. A good figure accompanies the description in the forthcoming part of the Proceedings of this Society. The occurrence of the Saiga Antelope in the British Pleistocene Fauna has long been anticipated, characteristic remains of the animal being well known from the caverns of France and Belgium; but Dr. Leeson's fine specimen affords the first proof of its range so far to the North-west of Europe as the present Thames Valley. This unique fossil, we understand, will be placed in the Twickenham Free Library.

OBITUARY.

CAV. ABÂTE ANTONIO STOPPANI.—It is with deep regret we have to record the death on January 1st, 1891, of Professor A. Stoppani, who held the chair of Geology in the Royal Superior Technical Institute in Milan, at the age of 66 years. Professor Stoppani was earnestly occupied in promoting, to the best of his ability, the publication of a fine series of Memoirs on Palæontology, especially on the Mammalian fauna of the Italian Tertiaries. It is to be hoped that his successor will take an equal interest in carrying on these important labours in the cause of science.

HENRY BOWMAN BRADY,

LL.D., F.R.S., F.G.S., F.Z.S., F.C.S., ETC.,

Was born at Gateshead, Newcastle-on-Tyne, February 23rd, 1835, and died at Bournemouth, January 10th, 1891. From his father, Mr. Henry Brady, who belonged to the Society of Friends, and who was a surgeon in extensive practice for fifty years, a true lover of nature, and accomplished botanist, he inherited similar tastes; and his love of Natural History, carefully nurtured at home and at school, strengthened with his years. His first schoolmaster was Mr. Storey, an ardent naturalist, and Mr. Thos. Belt, the naturalist of Nicaragua, was his school-fellow. After an apprenticeship to a chemist at Leeds, he studied under Dr. Thomas Richardson (the late Professor Marreco being a fellow-student) in the laboratory which afterwards became the Chemical Department of the College of Physical Science. After passing the examinations of the Pharmaceutical Society, he carried on the business of manufacturing and pharmaceutical chemist in Moseley Street, Newcastle, from 1855 to 1876, when he was succeeded by his friend Mr. N. H. Martin. Mr. Brady was Member of the Council and one of the Examiners of the Pharmaceutical Society. He was the originator of the Pharmaceutical Congress, and its President in 1872–3; and he contributed valuable papers to the Pharmaceutical Journal.

In his native city he lectured on Botany at the Durham College; and he was actively associated with the eminent naturalists—Alder, Albany and John Hancock, Howse, Hewitson, Wailes, Norman, G. S. Brady (his brother), Embleton, and others; and communicated papers, chiefly on recent Foraminifera, to the Natural History Society of Northumberland and Durham and the Tyneside Field-Club. Other papers he contributed to the British Association, the Royal Society, Linnean Society, Royal Microscopical Society, the Annals and Magazine of Natural History, the Geological Society, and the Geological Magazine. His chief work, however, has been the two magnificent quarto volumes of the "Challenger" Report on the Foraminifera collected in 1873–6. He began his labour of love in 1878, and supplied the manuscript for 814 pages of text, and superintended the 115 excellent plates, in 1882–4.[1] This most painstaking and conscientious work is a perfect storehouse of facts and philosophic deductions, and is the highest work on Foraminifera. His accumulated knowledge of these organisms and their extensive literature,—his own careful researches during voyages in many parts of the world,— and his friendly intercommunication with naturalists throughout Europe—enriched this noble work with very much that could not have been expected from any other naturalist.

Among his researches Mr. Brady frequently dealt with Fossil Foraminifera, and thereby did good service to Geology. Joining

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[1] The foregoing has been for the most part derived from the excellent and warm-hearted obituary in the "Newcastle Daily Journal" for January 15, 1891.

Professor W. Kitchen Parker and T. Rupert Jones in carrying on the memoirs on the Nomenclature of Foraminifera, he helped in elucidating many Tertiary species from Italy, treated of by Soldani, and from the Paris and Vienna Basins, described by d'Orbigny: Ann. Mag. Nat. Hist. 1865–71. With Parker and Jones he also produced a "Monograph on the Foraminifera of the Crag," Palæontographical Society. 1866 (incomplete); and a Monograph on the Genus *Polymorphina* (including fossil forms), Trans. Linn. Soc. vol. xxvii. 1870. With Dr. W. B. Carpenter he wrote the memoir on *Parkeria* and *Loftusia*, Philos. Trans. 1869. The most important of his other papers on Fossil Foraminifera are the following:—Foraminifera of the Lias of Somerset, Proc. Somers. Arch. N. H. Soc. vol. xiii. 1867.—*Saccammina Carteri*, Ann. Mag. N. H. March, 1871; *Archæodiscus Karreri*, A. M. N. H. October, 1873; and *Nummulina pristina*, A. M. N. H. March, 1874, all from the Mountain-limestone.—Tertiary and Carboniferous Foraminifera from Sumatra, GEOL. MAG. November, 1875.—*Fusulinæ* from Russia, A. M. N. H. November, 1876.—A Miocene Foraminifer from Jamaica, Ann. Malac. Soc. Belg. vol. xi. 1876.—Chalk (?) from the New-Britain Islands, GEOL. MAG. December, 1877.—The so-called "Soapstone" of Fiji, Quart. Journ. Geol. Soc. vol. xliv. 1888. His Monograph of Carboniferous and Permian Foraminifera (*Fusulina* excepted), published by the Palæontographical Society, 1876, is a standard work of very great use to Palæontologists. Gathering together and revising all that had been done on the subject, and giving careful descriptions and admirable figures of many forms not previously known, this handsome Monograph supplied a great want, and furnished a good standpoint for observers of Palæozoic Rhizopoda.

Thus, thanks to Mr. H. B. Brady's persistent energy and hard work, in spite of poor health and at times much suffering, students and others are provided, at several stages of the geological scale, with trustworthy data, in fossils of low type and small size, but of sufficiently distinct character, for guidance in speculating as to the depth and extent of the old seas, relative abundance of life, and evolution of organic forms.

Such results alone were deserving of great praise; and it is not surprising that, with his other more extensive researches on recent Foraminifera, Mr. Brady was welcomed as a Fellow of many Scientific Societies, and in 1888 honoured with a Degree from the old University of Aberdeen. In the same year, for the liberal and personal aid given by him to the Imperial Museum at Vienna, and his high standing in his long-continued scientific pursuits, a Gold Medal was presented to him by the Emperor of Austria. He was a Corresponding Member of the Imperial Geological Institute at Vienna; and Honorary Member of the Royal Bohemian Museum at Prague.

T. R. J.

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ORIGINAL ARTICLES.

I.—On the very Recent and Rapid Elevation of the Highlands of Eastern Asia.

By Henry H. Howorth, Esq., M.P., etc., etc.

AMONG the many interesting issues raised by the discovery of Mammoth remains in large numbers along the Arctic borders of Eastern Asia, one has, I think, ceased to be polemical. So far as I know, there is no serious student who now contests the fact that the Mammoth and his companions lived where their remains are found. The rooted trees upon which they fed, and the southern river-shells which were their contemporaries, both of which are found with their remains (both being incapable of migration), prove incontestably what a score of other arguments show, that the fauna of North-Eastern Siberia in the Mammoth age, like its flora, must be explained by some other theory than migration. This I have urged in many ways in my work on the Mammoth.

If the arguments I have recently adduced in the Geological Magazine to show that the two great rivers of Western Siberia flowed southwards and not northwards in the Mammoth age be sound, they give the finishing blow to what has virtually ceased for many other reasons to be a tenable theory, namely, that the Mammoth carcases and the vast débris of the animal world found on the mainland and on the islands off the coast of Siberia are the results of river portage. Against this last theory I have also tried to converge a large number of arguments, old and new, in the work just cited.

There remains only one possible conclusion, as I said at starting, namely, that the great beasts whose remains abound so much in the tundras east and west of the Lower Lena on the Bear Islands, etc., lived where their remains occur, as the Russian explorers and as our most experienced writers agree.

This conclusion necessitates our postulating that the area in question in the time when the Mammoth lived, instead of being as now a bare tundra covered with snow for the greater part of the year, and swept by icy winds, with a short summer of little more than six weeks, was sufficiently temperate in climate to permit an abundant and accessible vegetation to exist all the year round, not only up to the present border of the Arctic Sea, but right across from Siberia to Alaska. This deductive axiom is inductively proved by our finding the remains of this same vegetation rooted in the very beds where the Mammoths lie, and far beyond the present limit of forest growth. The fact has to be explained in some way by those students who do not emulate the conduct of the ostrich by hiding their heads in the sand to baffle every pressing difficulty, and who recognize that all hypotheses, however supported by authority, are in essence tentative.

How, then, are we to explain a change of climate so important and so considerable? What are the conditions which impose such a hard climate upon North-Eastern Asia, and under what hypothetical conditions could we reasonably postulate a fairly temperate climate in the Bear Islands, the Chukchi peninsula and Alaska? It seems to me that the severe climate of North-Eastern Asia is governed partially by the fact that that area is in close contact with and bounded on the north by the Arctic Sea, which is a reservoir of cold, and partially and probably to a greater extent by the fact that it is in close contact with and bounded on the south by the icy plateaux of Mongolia and Tibet. It seems to me, further, that if we could remove these two sources of cold, we should at once transform the climate of the district we are discussing from one of extreme Arctic severity to one of a moderate and perhaps even temperate character.

I will first say a few words about the Polar Sea. It is an opinion very generally held that a continental climate presents much greater contrasts, and is in effect more severe than a maritime or insular climate, which has its extremes tempered by the continued presence of water, and the isothermal lines of the world are a singular proof of the general truth of the position. The position is nevertheless only partially true. It is only true when the water is in the shape of water. When the water is frozen and remains frozen all the year round, and is consequently *never* above the freezing-point, but always below it, the proximity of a great mass of water, instead of acting as a tempering instrument, acts as a perpetual refrigerator, and every wind that blows across it and over the land is an icy cold wind. Hence the Polar Sea, so long as it remains frozen, has the effect of greatly intensifying the natural climate due to a high latitude; and if it were removed, and replaced by a mass of land, the effect would be much the same as if its waters were unfrozen: the result would be in fact to greatly temper the climate.

I have tried to show in a previous paper that when the Mammoth lived, the polar area, or a considerable portion of it, was necessarily dry land, otherwise that animal and its companions could not have passed to and fro between Siberia and America, as we know they did, and as we also know they did in very high latitudes. Hence, it follows that when the Mammoth lived, either there was no Polar Sea, or its area was greatly contracted, and thus this reservoir of cold did not exist to continually sophisticate the north wind with its icy touch. *Pro tanto* the effect of this must have inevitably been to modify the climate in the direction of making it more temperate and genial.

This I have urged before in these pages. We must not, however, exaggerate this cause, and attribute it to more than it can explain.

When we inquire why the climate of the valley of the Lower Lena, and notably Yakutsk, should be so exceptionally severe, as compared with almost every other place on the same parallel of latitude, we shall find that it is due not so much to the prevalence of excessively cold north winds, but to the prevalence of excessively cold south winds: especially is this the case in summer, when in many other areas on the same parallel the south wind brings a balmy memory of the tropics with it. Here it always comes from the sterile cold plateau of Tibet. It then flows across the Mongolian highlands, and, after blowing over such a wide space of very elevated land, it is not only drained of its moisture, but is also cooled down to a low temperature. Hence at Yakutsk the south wind is often nearly, if not quite, as terrible a visitor as the north wind.

If therefore we are to trace the present severity of the climate of North-Eastern Asia to its most potent and efficient cause, we must trace it to the existence of vast masses of mountain land and high plateaux culminating in the Thian Shan, the Kuen Lun, and the Himalayas and including the Altai range and the great upland steppes of the Pamir of Tibet and of Mongolia proper.

So long as this vast refrigerator exists in Asia, so long does it seem to me must the climate of North-Eastern Siberia remain a very cold and severe climate, and one incompatible with vast herds of herbivorous animals finding suitable food in the latitude of the Bear Islands; and if we are to find the efficient and real cause of a once temperate climate, where everything is now so palpably the reverse, we must inevitably postulate the non-existence in the Mammoth age of these great masses of high land. I have no hesitation in doing so. The suggestion was made long ago as a suggestion merely, by a much greater man than myself, whose sobriety of argument and ripe judgment have been somewhat overshadowed lately by more imaginative forms of scientific reasoning. I mean Alexander von Humboldt. Humboldt argued that the rise of the Ural and Altai Mountains, and with them of enormous masses of the continent of Asia, must have so refrigerated Siberia, that its forests, which in the halcyon days of Mammoths may have extended in certain promontories to near the Icy Sea, had necessarily shrunk back to their present limits, and left these coasts entirely to the Reindeer and its mosses (Russia and the Ural Mountains, vol. ii. p. 497). Let us now see how this view can be supported inductively.

The first remarkable fact to which I would call attention is one that arrested notice long ago, namely, that in the Altai Mountains, which are very lofty and otherwise well adapted to nurse large glaciers, no traces of the so-called Glacial Age can be found. No striated rocks, no ancient boulders. This is assuredly a remarkable fact. It is attested by more than one reputable witness. One of the first trained geologists who visited the Altai Mountains was Pierre de Tchihatcheff, who published a very fine work on that chain in 1845. He remarked in it on the absence from the Altai as from the Ural chain of any erratic blocks so far as his observations went (*op. cit.* pp. 396–7). In 1871 another special work on the geology of the Altai was published at Leipzig by the famous geologist Bernhard von Cotta. *Inter alia,* he remarks on the complete absence in the Altai of any traces of a Glacial age, or of such evidences of an Ice age as exist in Western Europe. He says that General von Helmersen had failed to find any traces of erratic blocks of rounded rocks or of polished surfaces; while he himself, in spite of an eager search, had "not been able to find the slightest evidence of anything of the kind either in the subordinate ranges and hills or the deeper valleys, although the mountains there are from seven to eleven thousand feet high, and at present a few small glaciers are to be found in the south-eastern part of the range; and," he adds, "those who would explain the absence of old glacial action in the Urals from the fact of their comparatively low altitude cannot use the same argument here." In another place Von Cotta remarks again on the fact that the Altai range offers no traces of a former Glacial period or of an Ice age (vide *op. cit.* pp. 65 and 107).

The two ranges of the Urals and the Altai therefore share in this common absence of traces of a so-called Glacial age, an absence which is also marked, as Humboldt long ago pointed out, in the plains which separate the two ranges. All this is assuredly very remarkable. That a vast congeries of mountains should have existed in the temperate zone of the northern hemisphere at the time when the Alps and the Dovrefelds were shedding their great trains of erratics far and wide and were covered with vast glaciers, and yet that there should be no traces of old glacier action among them, is explainable to myself by no other hypothesis than their non-existence at the time. As in the case of the Urals, to which I devoted the previous paper, the absence of traces of ice action is the best evidence that the Altai range did not exist when ice action was so developed on nearly every secondary mountain chain in the north temperate zone.

Again, it is a remarkable fact that among the animal remains found in the Altai caverns the Hyæna should occur. The Hyæna is, I believe, very rarely if ever found in the caverns on the flanks of the Alps or in those of the higher grounds of Germany, and was a frequenter of the warmer plains. That it should occur in the caverns of the Altai points again to that area having had a different contour to the present one. Altogether, it seems to me that in regard to the Altai range, such evidence as we have is completely consistent with the *à priori* view that these mountains did not exist during the Mammoth age.

If we turn from the Altai range to the mighty plateau which forms the great mass of Central Asia, and is buttressed on the south by the Himalayas, on the north by the Thian Shan range, on the west by the Pamir and the Hindu Kush, and on the east by the mountains of Corea, we have to deal with an area which has only been visited and traversed at a few points. The testimony of travellers, however, seems to be unanimous, whether they approach this great upland from India, or Russia, or China, namely, in vouching for the absence of those most easily distinguished and most palpable proofs of wide glaciation which we meet with in Western Europe and in Eastern America.

The Russian traveller Severtzoff has described the existing glaciers of the Thian Shan, some of them still of enormous size, some shrinking and recently shrunk, in consequence doubtless of the gradual desiccation of the surrounding lowlands and consequent diminution of moisture.

When he turns to a former development of glaciers, which ought assuredly to have left enormous traces in this the very focus of modern glacier action, at a time when Central Asia, instead of being a dried-up waste, was occupied by a vast sheet of water, and when the conditions for the growth of glaciers were so favourable, what does Severtzoff say? I will copy his account, as communicated by Krapotkin to Reclu's great geographical work.

"Evidently the Thian Shan," he says, "has preserved its primitive aspect better than the Alps. It has been less carved out by rain, snow, and glaciers. While the névés and rivers of ice in the Alps once covered the plains and lowlands surrounding that range to a height of 200 metres, the glaciers of the Celestial mountains do not appear to have descended into the lower valleys, and a vigorous vegetation occupied the flanks of the mountains to a height of 750 metres above the level of the waters which bathed their feet. There has, in consequence, resulted a very different law of vegetable distribution. While the Alpine region has been itself colonized by species of plants growing in the forest outside it during the intensity of the ice, the zone of the Lower Thian Shan was the mother country whence species spread in one direction towards the higher summits, and in the other towards the dried-up plains."—(Severtzoff quoted by Reclus, Nouvelle Geographie Universelle, vol. vi. pp. 359–360.)

It would not be easy to adduce stronger evidence than this that on the great ramparts of mountains which form the northern frontier of the great Asiatic plateau there is not only an absence of traces of former great glacial development, but positive proof that no such conditions could have then existed.

If we turn to the other extremity of this great plateau girdled with mountains, namely, to Corea, we find the same story. Dr. Gottsche, in his memoir entitled Geologische Skizze von Korea, published in the 36th volume of the Proceedings of the Berlin Academy, says emphatically, "Glacial phenomena do not exist in Corea," and he quotes Richthofen's China, vol. ii. p. 111, as witnessing to the absence of similar phenomena from Liautung. Both Corea and Liautung are mountainous countries, and the former very much so.

If we now turn to the great southern buttresses of the Asiatic plateau, namely, the Himalayas, we shall find a repetition of what Severtzoff reports in regard to the Thian Shan range, namely, a large number of glaciers showing signs of shrinkage, of which Mr. Lydekker has given a very interesting conspectus. No doubt there are traces of their having been bigger and stretched further, but these traces are nevertheless strangely limited in extent, considering the huge reservoirs of ice which the Himalayas must have been, in the so-called Glacial age, if the same conditions had prevailed there as prevailed in corresponding times in the Alps. We must not forget that not only was the southern monsoon there with its heavy rains, but the Asiatic Mediterranean was also then existing, so that we must not measure the amount of moisture then prevailing with what prevails now; and what is the testimony of the best observers on the subject? There has no doubt been a polemic in which many writers, such as Theobald, Wynne, Lydekker, Drew, and others have joined; but this has been rather about the extent to which the modern glaciers have shrunk: all admit recent glaciation in the higher valleys, but I know of no Indian geologist, except Mr. Theobald, who has contended for signs of vast glaciation, such as we find in the much smaller European ranges of the Alps and Dovrefelds. I would add that Strachey has published in the Encyclopædia Britannica a very useful diagram showing the comparative size of the Alps and the great Asiatic uplands, which is a very useful measure of the kind of traces of a glacial age we ought to meet in Eastern Asia. To revert, however: there is a general concurrence among observers that the phenomena in the Himalayas are on quite a small scale *comparatively*.

Thus, Mr. J. F. Campbell writes: "The Himalayan region is a slope about 200 miles wide between the upper plateau of Asia and the plains of India . . . . I looked at every stone and heap of stones about the foot hills, expecting to find some glacial mark. I looked at every hill top, expecting to find some remnant of a glacial record between the river gorges. . . . I stayed at Simla for some time, and found no sign of glacial action of any kind up to about 9000 feet. All the ridges which divide streams are sharp and steep as the ridge of a house. All the furrows are deep V-shaped, angular, steep gutters, like the gutter between two steep roofs. I could not discover one rounded hill or hollow, one 'saddle' or 'hogback,' from Simla, or from places near it to which I could travel . . . . The highest ground visible is a jagged sierra of pyramidal angular points, among which are the glaciers" (Quart. Journ. G. S. vol. xxxv. pp. 109–110). "Hirdswar is a sacred place where the Ganges leaves the hills. At the sources of the Ganges are glaciers. If these glaciers ever extended far during a Glacial period, some mark ought to be found about the place where a river as big as the chief river of Lombardy at its greatest size escapes from the great basin, whose jagged edges and steep sides I had seen from Landour, where frosts and deep snows occur frequently. In a like position in Italy, near Turin, are ramparts of glacial débris. Hirdswar is 1124 feet above the sea. The edge of the basin is nearly 20,000 feet higher, and the area is large and comparable to the area of the Val d'Aosta or the Lago Maggiore. . . . . I stayed at Hirdswar for several days, and could find no sign of glacial action whatsoever" (*id.* pp. 113–114).

At Roorkee, in digging a huge canal, there was found only mud, sand, pebbles, and abundance of large, smooth, egg-shaped, rolled stones of considerable size. "I could not find," says Mr. Campbell, "one stone with scratches on it or with flat sides, or one angular erratic near the canal. I could find nothing glacial about the end of the Ganges basin. I could hear of nothing glacial from the surveyors with whom I conversed at Dehra. I had photographs of glaciers, and of glens near them, about the headwaters of the Ganges and the Sutlej. In them I could see nothing to suggest the former action of large glaciers like those which have left their spoor in the Alps, in Scandinavia, in Scotland, and in Ireland. In some few pictures only I could trace marks which seem to indicate a former extension of glaciers which exist. Captain Senior, who made the pictures, said that old glacier-marks *extend only a few miles from the ice in this region.* The surveyors who mapped the ground confirmed what I saw and heard. The Ganges glaciers and others in this region hang about the steep broken edges of great deep basins; and there is nothing to show that glaciers ever filled these basins, as European hollows were filled of old. Opposite to the Ganges there are no signs of that Glacial period to which European ice-marks are usually attributed." Again, "I crossed the Jumna, the Sutlej, and the Bias, about fifty miles from the hills. I saw no glaciated stones in the plains or near the banks of these three great rivers, all three rising among glaciers. There is nothing at the foot of the Himalayas here comparable to the glacial débris of Lombardy or the erratics of the American plains" (*id.* p. 114). "The Ravee (within sight of the Kashmir hills) rises among glaciers; but there is nothing like glacial work opposite to this great river-basin in the plains. In the Kangra valley there was no sign of a great glacier passing along the base of the Sutlej valley from east to west. Such a glacier, if it ever existed, must have left a conspicuous mark. So far as I have been able to learn from surveyors, geologists, travellers, photographers, and photographs, there are no marks of a big glacier in the Sutlej valley so far as it has been explored, but existing glaciers are close at hand" (*id.* p. 115).

In regard to the famous deposit of rounded stones in this valley, about which so much has been written and said, the same acute and experienced observer writes that "at first sight these stones by their great size suggested glacial action. They have been described as erratics, and the deposits in which they occur as 'moraines' of the Glacial period. I therefore sought carefully, but I could find none of the known marks. The Kangra big stones are all smoothed, dinted, and rounded; the biggest are next to the range. The size decreases as the distance increases, and the slopes grow less. They are not arranged like moraines at Turin or elsewhere, but spread like stuff of the same kind at the foot of the Pike's Peak in America, and at the end of the Dariel Pass in the Northern Caucasus. The deltas to which these trains of big stones belong all spread like fans from the jaws of deep, steep ravines near high, steep hills, and they are all washed and rolled by floods of water. . . . ."

At Dhada, a rest-house at the foot of the high range, "a gravel-pit has been described by a very experienced geologist as one of the Kangra moraines. The solid rock under the loose stuff was newly laid bare. It is *not* glaciated. The whole of the stuff was sorted by running water, and the big stones strewed on the top evidently are the largest and heaviest in an old river deposit laid bare by late rains which have washed away smaller stuff. There was no moraine stuff in the section, no clay, and no scratched stones anywhere."

Mr. Campbell is most emphatic in his conclusion that the Himalayas present us with no evidence of a Glacial period. Glaciers exist there, and may have been larger. "While," he says, "Scandinavian and Alpine ice has shrunk by many meridian degrees, old Himalayan glaciers have left no mark within a few miles. It seems as reasonable to account for the length of an icicle by a Glacial period, as to summon that cause to account for any extension of Indian ice of which I was able to obtain proofs, from maps and surveyors, geologists and papers, photography and photographers, and travellers" (*id.* p. 118).

(*To be continued in our next Number.*)

II.—NOTES ON SOME FISH-REMAINS FROM THE LOWER TERTIARY AND UPPER CRETACEOUS OF BELGIUM, COLLECTED BY MONSIEUR A. HOUZEAU DE LEHAIE.

By ARTHUR SMITH WOODWARD, F.G.S., F.Z.S.

(PLATE III. FIGS. 1–17.)

SOME time ago the writer was favoured by Monsieur A. Houzeau de Lehaie with the opportunity of studying his extensive collection of teeth and other remains of fishes from the Bruxellian Eocene, near Brussels, and the "Craie brune phosphatée de Ciply," near Mons. Monsieur Houzeau has generously presented a fine series of these fossils to the British Museum, and the following notes are based upon the collection.

I. THE FISH-FAUNA OF THE BRUXELLIAN EOCENE.

Like the contemporaneous Bracklesham Beds in England, the Bruxellian Sands of Woluwe St. Lambert, near Brussels, yield only very fragmentary remains of fishes. These have been studied more especially by M. H. Le Hon[1] and Dr. T. C. Winkler;[2] and MM. P. J. Van Beneden[3] and L. Dollo[4] have contributed additional notes.

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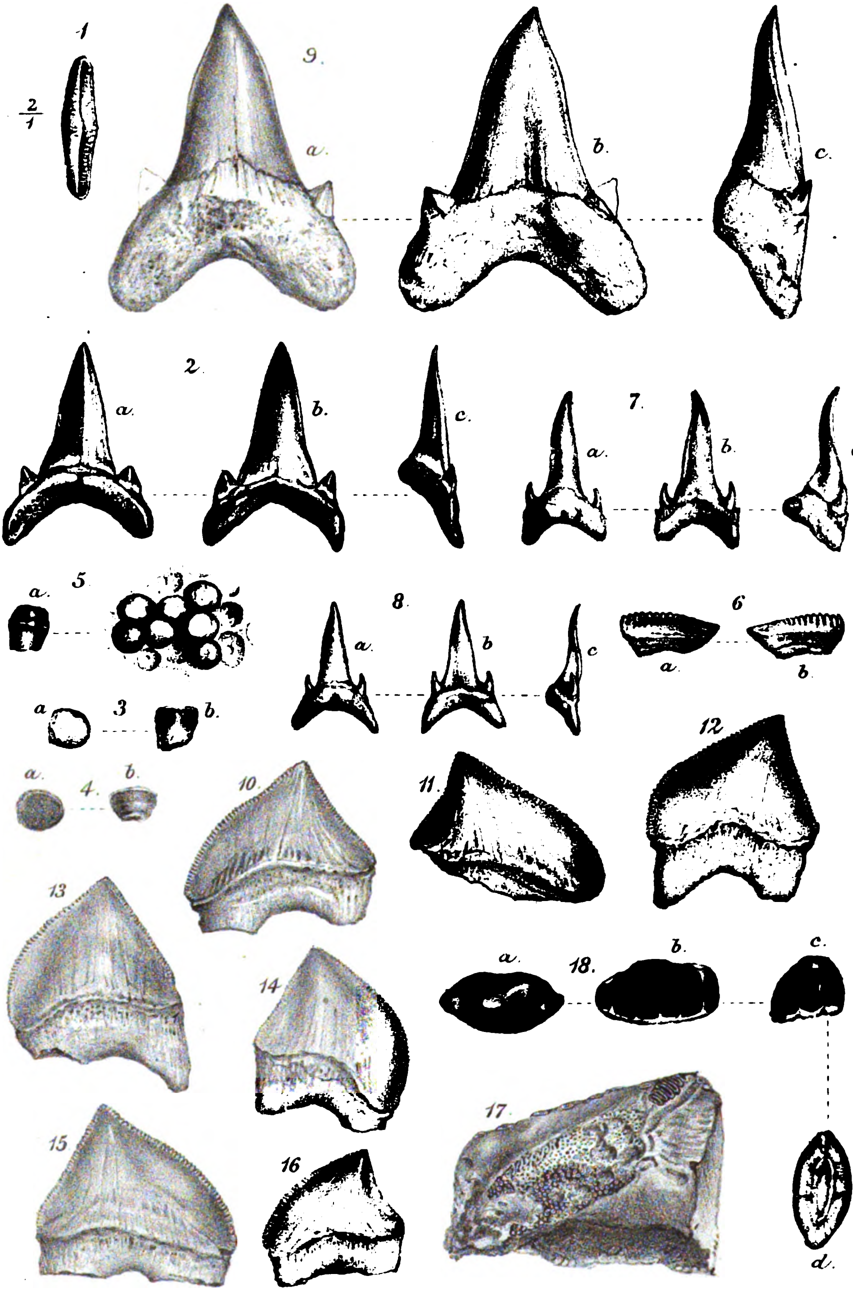
[1] H. Le Hon, "Préliminaires d'un Mémoire sur les Poissons Tertiaires de Belgique" (1871).

[2] T. C. Winkler, "Mémoire sur des Dents de Poissons du Terrain bruxellien," Archiv. Mus. Teyler, vol. iii. (1874), pp. 295–304, pl. vii.; also *ibid.* vol. iv. (1876), pp. 16–48, pl. ii.

[3] P. J. Van Beneden, "Recherches sur quelques Poissons fossiles de Belgique," Bull. Acad. Roy. Belg. [2], vol. xxxi. (1871), pp. 153–179. Also "Notice sur un nouveau Poisson du Terrain bruxellien," *ibid.* vol. xxxv. (1873), pp. 255–259, with plate (*Homorhynchus bruxelliensis*).

[4] L. Dollo, "Première Note sur les Téléostéens du Bruxellien (Eocène moyen) de la Belgique," Bull. Soc. Belg. Géol. etc. vol. iii. (1889), Proc.-Verb. pp. 218–226 (*Arius Egertoni*).



Berjeau & Highley del. et lith Hanhart imp.

1-17. BELGIAN EOCENE AND CRETACEOUS FISHES.
18. DENTAL CROWN OF BOTTOSAURUS BELGICUS, sp. nov.

Several of the original determinations of the fossils were based upon insufficient comparisons, and have subsequently proved erroneous; and the examination of M. Houzeau's collection now enables the present writer to confirm and extend the revision commenced by recent authors.

ELASMOBRANCHII.

Cestracion Duponti, Winkler. Pl. III. Fig. 1.

1876. *Cestracion Duponti*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. p. 17, pl. ii. figs. 1-3.

Some anterior prehensile teeth of *Cestracion* have already been described and named *C. Duponti* by Dr. Winkler; and it is interesting to find in M. Houzeau's collection one of the crushing teeth so characteristic of the middle portion of each ramus of the jaw in this genus. The specimen measures 0·0095 in length and 0·003 in maximum breadth, and is shown from the coronal aspect, of twice the natural size, in Pl. III. Fig. 1. Having been discovered in the same formation and locality as the prehensile teeth, and agreeing with the latter in its comparatively small size, the new specimen may also be named *C. Duponti*, and thus adds somewhat to the scanty definition of the species. The tooth tapers gradually to its extremities, which are obtusely angulated, almost rounded; and there is a prominent median longitudinal keel, which rises to a blunt apex at the point of maximum breadth. The coronal surface is also coarsely rugose.

It is interesting to observe that the crushing tooth just described corresponds more closely with those of the Cretaceous species than with those of the existing forms; and it may be added that a similar tooth has already been recorded from the London Clay of Highgate Archway.[1]

Odontaspis elegans (Agassiz).

1843. *Lamna elegans*, L. Agassiz, Poiss. Foss. vol. iii. p. 289, pl. xxxv. figs. 1-5 (*non* figs. 6, 7), pl. xxxvii *a*. fig. 59 (*non* fig. 58).
1871. *Lamna elegans*, H. Le Hon, Prélim. Mém. Poiss. Tert. Belg. p. 12.
1875. *Lamna elegans*, A. Rutot, Ann. Soc. Géol. Belg. vol. ii. p. 34.
1876. *Otodus striatus*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. pp. 8, 24, pl. i. figs. 7-9.
1876. *Lamna elegans*, T. C. Winkler, *ibid.* p. 9.
1876. *Lamna elegans*, G. Vincent, Ann. Soc. Roy. Malacol. Belg. vol. xi. p. 123, pl. vi. fig. 4.
1876. *Otodus striatus*, G. Vincent, *ibid.* p. 125, pl. vi. fig. 2.
1880. *Lamna elegans*, T. C. Winkler, Archiv. Mus. Teyler, vol. v. p. 74.
1885. *Lamna elegans*, F. Noetling, Abh. Geol. Specialk. Preussen u. Thüring. Staaten, vol. vi. pt. 3, p. 61, pl. iv.
1889. *Odontaspis elegans*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. i. p. 361.

Typical teeth of this species occur, and it seems most probable that the teeth named *Otodus striatus* by Winkler are truly referable to the sides of the upper jaw of the same fish. Noetling has attempted to restore the dentition from the fossils of the Eocene of Samland, placing relatively low-crowned and broad compressed teeth in the upper jaw,—an arrangement agreeing precisely with that of the existing species of *Odontaspis*. Notwithstanding recent criticisms,[1] we still venture to maintain that the form of the anterior teeth proves the species to be referable to the last-mentioned genus, and not to *Lamna*.

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[1] Catal. Foss. Fishes Brit. Mus. pt. i. p. 336.

Oxyrhina nova, Winkler.

1876. *Oxyrhina nova*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. p. 22, pl. ii. fig. 8.

This species may be accepted as well defined.

Oxyrhina Desori, Agassiz.

1843. *Oxyrhina Desorii*, L. Agassiz, Poiss. Foss. vol. iii. p. 282, pl. xxxvii. figs. 8-13.
1885. *Oxyrhina xiphodon*, F. Noetling, Abh. Geol. Specialk. Preussen u. Thüring. Staaten, vol. vi. pt. 3, p. 50, pl. iii.
1889. *Oxyrhina Desorii*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. i. p. 382.

Some broad upper lateral teeth of this species occur in M. Houzeau's collection, and resemble those figured by Noetling (under the name of *Oxyrhina xiphodon*) from the Samland Eocene.

Lamna verticalis, Agassiz. Pl. III. Fig. 2.

1843. *Lamna* (*Odontaspis*) *verticalis*, L. Agassiz, Poiss. Foss. vol. iii. p. 294, pl. xxxvii *a*, figs. 31, 32.
1874. *Otodus minutissimus*, T. C. Winkler, Archiv. Mus. Teyler, vol. iii. p. 297, pl. vii. fig. 2.
1876. *Otodus parvus*, T. C. Winkler, *loc. cit.* vol. iv. p. 7, pl. i. figs. 5, 6.
1876. *Otodus minutissimus*, T. C. Winkler, *ibid.* p. 23.
1880. *Odontaspis mourloni*, T. C. Winkler, *loc. cit.* vol. v. p. 77, figs. 1, 2.
1883. *Lamna* (*Odontaspis*) *verticalis*, W. Dames, Sitzungsb. k. preuss. Akad. Wiss. Berlin, pt. i. p. 145, pl. iii. figs. 8–10.
1886. *Odontaspis minutissimus*, F. Noetling, Sitzungsb. naturf. Freunde Berlin, p. 16.

The large series of teeth of this species in M. Houzeau's collection seems to justify the above synonymy suggested by Prof. Dames. The form and proportions of the anterior teeth are characteristic of the true *Lamna*; and a typical lateral tooth is shown, of the natural size, in Pl. III. Fig. 2.

The type specimens of *L. verticalis* are stated by Agassiz to have been obtained from the London Clay of Sheppey, but the present writer has not been able to identify teeth of this form from any British Eocene deposit.

Lamna Vincenti (Winkler).

1876. *Otodus Vincenti*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. p. 25, pl. ii. figs. 9–10.

The teeth of this species exhibit no characters by which they can be separated from those of the true *Lamna*. They are well characterized by Winkler, though a reference might have been made to the supposed species, *Lamna compressa* of Agassiz. The latter comprises teeth of very similar proportions but distinguished by the form of the lateral denticles; and there cannot be much doubt that most of these fossils are referable to the upper jaw of *Lamna macrota.*

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[1] J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. iv. (1890), pp. 373, 398.

Ginglymostoma thielense (Winkler).

1874–76. *Plicodus thielensis*, T. C. Winkler, Archiv. Mus. Teyler, vol. iii. p. 301, pl. vii. fig. 5, and *ibid.* vol. iv. p. 20.
1886. *Ginglymostoma thielense*, F. Noetling, Sitzungsb. Ges. naturf. Freunde Berlin, p. 14, figs. 2, 3.

The teeth described under this specific name exhibit all the characters of *Ginglymostoma*, as already noted by Noetling.

Scymnus trituratus (Winkler).

1874. *Corax trituratus*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. p. 27, pl. ii. fig. 13.
1879. *Scymnus trituratus*, J. Probst, Württ. Jahresh. vol. xxxv. p. 176.
1886. *Scymnus trituratus*, F. Noetling, Sitzungsb. Ges. naturf. Freunde Berlin, p. 17.

Some very small Bruxellian teeth are indistinguishable in shape from those of the existing *Scymnus*, and may thus be regarded as pertaining either to this genus or to a closely allied form at present undetermined.

Squatina, sp.

A tooth of *Squatina* occurs in M. Houzeau's collection, but cannot be regarded as sufficient for specific determination. It is less robust than the teeth of the same genus from the Heersian Beds,[1] and similarly differs from a Belgian Pliocene tooth described by Le Hon.[2]

Cœlorhynchus rectus, Agassiz.

1784. "Pétrification inconnue," Burtin, Oryctogr. Bruxelles, pl. vi. figs. A–E.
1844. *Cœlorhynchus rectus*, L. Agassiz, Poiss. Foss. vol. v. pt. i. p. 92 (name only).
1850. *Cœlorhynchus*, F. Dixon, Foss. Sussex, p. 112, pl. x. figs. 14–17, pl. xi. fig. 26.
1871. *Cœlorhynchus rectus* and *C. Burtini*, H. Le Hon, Prélim. Mém. Poiss. Tert. Belg. p. 14; also P. J. Van Beneden, Bull. Acad. Roy. Belg. [2], vol. xxxi. p. 500.

No specific differences between *C. Burtini* and the typical *C. rectus* have been pointed out, and they may be regarded as pertaining to one and the same form.

TELEOSTOMI.

Lepidosteus, sp.

1874. *Trichiurides sagittidens*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. p. 31, pl. ii. figs. 22, 23.
1883. "*Lepidosteus*-verwandter Ganoid," Hilgendorf, Zeitschr. deutsch. geol. Ges. vol. xxxv. p. 670.

As already recognized by Hilgendorf, the teeth described by Winkler under the name of *Trichiurides* are indistinguishable from those of *Lepidosteus*. Numerous teeth, head-bones, scales, and vertebræ closely resembling those of the latter genus are well known from several European Lower Tertiary formations; and a single vertebra has been recorded from the Bracklesham Beds.[1]

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[1] *Trigonodus primus*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. (1876), p. 14, pl. i. figs. 18-21.

[2] *Scaldia biforis*, H. Le Hon, Prélim. Mém. Poiss. Tert. Belg. (1871), p. 7, with figs.

Pisodus Oweni, Owen. Pl. III. Figs. 3–5.

1844. *Pisodus Owenii*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 247 (name only).
1845. *Pisodus Owenii*, R. Owen, Odontography, p. 138, pl. xlvii. fig. 3; also Cat. Foss. Rept. and Pisces Mus. R. Coll. Surgeons (1854), p. 167.

Numerous detached teeth occurring in the Bruxellian of Woluwe St. Lambert are identical with those of the peculiar dental armature described by Owen from the London Clay of Sheppey under the name of *Pisodus*. Two of these specimens are shown of the natural size in Pl. III. Figs. 3, 4, and a portion of the typical dentition from Sheppey is represented for comparison in Fig. 5. The teeth are rounded or irregularly angulated, while the superficial gano-dentine is thin and soon removed by wear. The greatest diameter of the tooth is at the base of the crown, and the hollow root tapers below to its point of attachment to the bottom of a socket in the supporting bone.

The affinities of *Pisodus* seem to have hitherto escaped recognition, but a fine skull from Sheppey in the British Museum (No. 39439) shows that in all essential cranial characters it is identical with the existing Elopine Clupeoid, *Albula*. The peculiar tritoral dentition occurs upon the parasphenoid bone, and is precisely similar to that of the last-named genus.

Ancistrodon fissuratus (Winkler).

1852. *Sargus? armatus*, P. Gervais (*errore*), Zool. et Pal. Franç., Explic. p. 5, pl. lxix. figs. 9, 10.
1852. *Sargus? serratus*, P. Gervais (*errore*), *ibid.* p. 2, pl. lxvii. fig. 8.
1874. *Corax fissuratus*, T. C. Winkler, Archiv. Mus. Teyler, vol. iii. p. 299, pl. vii. fig. 4.
1876. *Corax fissuratus*, T. C. Winkler, *loc. cit.* vol. iv. p. 12, pl. ii. figs. 11, 12.
1883. *Ancistrodon armatus*, W. Dames, Zeitschr. deutsch. geol. Ges. vol. xxxv. p. 664, pl. xix. fig. 2.

As pointed out by Dames the specimens named *Corax fissuratus* by Winkler are truly pharyngeal teeth of a teleostean fish, and may thus be assigned to the provisional "genus" *Ancistrodon*. They are identified by Dames with three teeth from the Nummulitic Series of the Dept. Aude and Cuise-la-Motte, erroneously associated by Gervais with teeth of *Sargus* and other genera under the names of *Sargus? armatus* and *Sargus ? serratus*.

Phyllodus, sp.

1876. *Phyllodus Deborriei*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. p. 28, pl. ii. figs. 14–18.

Though undoubtedly referable to the typical *Phyllodus*, the pharyngeal dentition described by Winkler is too imperfectly known for specific determination.

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[1] Woodward and Sherborn, "Catalogue of British Fossil Vertebrata" (1890), p. 111.

Cybium (?) sp.

1876. *Enchodus Bleekeri*, T. C. Winkler, Archiv. Mus. Teyler, vol. iv. p. 43, pl. ii. figs. 24, 25.

The complete dentition of the Cretaceous genus *Enchodus* being now known,[1] it is evident that the teeth named *E. Bleekeri* are incorrectly determined. These specimens doubtless pertain to a typical Scomberoid, and may be provisionally assigned to *Cybium*, which is already known to occur in the Lower Tertiaries elsewhere.

Sargus, sp.

A few anterior teeth exhibit so much similarity to those of the existing *Sargus*, that either this genus or *Lethrinus* may be recorded as occurring in the Bruxellian Fauna. The genus has already been determined by Agassiz[2] from the Eocene of Montmartre; and Gervais[3] figures some anterior teeth from the Nummulite-bearing beds of the Dept. Aude.

Trigonodon serratus (Gervais). Pl. III. Fig. 6.

1852. *Sargus? serratus*, P. Gervais, Zool. et Pal. Franç., Explic. p. 2, pl. lxvii. fig. 7 (*non* fig. 8).

Very broad cutting teeth much resembling the incisors of *Sargus* and its allies, are met with in several Tertiary formations; but they cannot be referred to any known existing genus, since they appear to have formed only a single pair in each jaw. Very similar teeth, though somewhat more robust, also occur in the Upper Cretaceous of Northern Africa, and are regarded as the type of an otherwise unknown genus *Stephanodus*, by von Zittel,[4] who states that they are associated with rounded and oval crushing teeth, probably referable to the inner part of the mouth of the same fish.

Several of these teeth occur in M. Houzeau's collection from the Bruxellian Eocene, and one example is shown, of the natural size, from the outer and inner aspects, in Pl. III. Fig. 6. The trenchant border of the crown is nearly parallel to its basal margin, but is much longer than the latter, which equals in length the comparatively small root to which the crown is firmly united. Each tooth meets its fellow of the opposite side in a narrow curved symphysis in front, and is produced posteriorly into an acute termination. The superficial gano-dentine is smooth, but the trenchant border is prominently and delicately crimped, the numerous vertical folds terminating in serrations, which soon become obliterated by wear. Some of these teeth, indeed, are worn down to short stumps, and it is interesting to observe that the oblique surface of abrasion first appears posteriorly.

An extremely worn tooth of the general form just described, from the Lower Tertiary of Piedmont, is regarded as the type of a genus

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[1] Smith Woodward, "A Synopsis of the Vertebrate Fossils of the English Chalk," Proc. Geol. Assoc. vol. x. (1888), p. 315, pl. i. figs. 5, 6.

[2] L. Agassiz, Rech. Poiss. Foss. vol. iv. (1839), p. 168, pl. xviii. fig. 1.

[3] P. Gervais, Zool. et Pal. Franç. (1852), pl. lxix. figs. 14–16.

[4] K. A. von Zittel, Handb. Palæont. vol. iii. (1888), p. 298.

Trigonodon by Sismonda;[1] and a tooth specifically indistinguishable from those of the Bruxellian is made known by Gervais from Cuise-la-Motte under the name of *Sargus? serratus*. The Middle Eocene fish under discussion must thus be termed *Trigonodon serratus*. Whether the more robust and coarsely denticulated character of the teeth described as *Stephanodus* justifies the recognition of this latter genus must be determined by future discoveries of more satisfactory specimens.

The most elaborate list of the typical Bruxellian Fish-fauna hitherto published is that of MM. A. Rutot and G. Vincent, contributed to Mourlon's "Géologie de la Belgique" (1880), p. 168. In conclusion, it may therefore be of interest to revise this enumeration of species in accordance with the latest researches:—

ELASMOBRANCHII.
Pristis Lathami, Galeotti.
Squatina, sp.
Myliobatis toliapicus, Ag.
—— *Dixoni*, Ag.
Aetobatis irregularis, Ag.
Cestracion Duponti, Winkl.
Scymnus trituratus (Winkl.).
Ginglymostoma Thielense (Winkl.).
Odontaspis elegans (Ag.).
—— *cuspidata* (Ag.).
Oxyrhina Desori, Ag.
—— *nova*, Winkl.
Lamna verticalis, Ag.
—— *macrota* (Ag.).
—— *Vincenti* (Winkl.)
Carcharodon heterodon, Ag.
Galeocerdo latidens, Ag.
—— (? *Protogaleus*) *minor*, Ag.

CHIMÆROIDEI.
Edaphodon Bucklandi, Ag.

ICHTHYODORULITE.
Cœlorhynchus rectus, Ag.

TELEOSTOMI.
Lepidosteus, sp.
Pycnodus toliapicus, Ag.
Arius Egertoni (Dixon).
Pisodus Oweni, Owen.
Ancistrodon fissuratus (Winkl.).
Trigonodon serratus (Gerv.).
Sargus, sp.
Cybium (?) sp.
Brachyrhynchus solidus, v. Ben.
Homorhynchus bruxelliensis, v. Ben.
Phyllodus, sp.

The so-called *Trigonodus secundus*, Winkl., *T. tertius*, Winkl., and *Gyrodus navicularis*, Winkl., require further examination.

II. THE FISH-FAUNA OF THE DANIAN OF CIPLY.

M. Houzeau's collection comprises teeth and other remains from two horizons in the Ciply series—the "Craie brune phosphatée" and the overlying *remanié* bed known as the "Poudingue de la Malogne." The latter is evidently derived, at least in great part, from the former, and its fish-remains are essentially the same. Seven species only seem to be worthy of special note.

ELASMOBRANCHII.

Scapanorhynchus rhaphiodon (Agassiz).

1843. *Lamna* (*Odontaspis*) *raphiodon*, L. Agassiz, Poiss. Foss. vol. iii. p. 296, pl. xxxvii *a*. figs. 12–16 (*non* fig. 11).
1889. *Scapanorhynchus rhaphiodon*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. i. p. 353.

As proved by the beautifully preserved species from the Upper Cretaceous of Mount Lebanon, it is impossible to determine the species of *Scapanorhynchus* merely by isolated teeth; and the attempt made by the present writer in the work cited to assign limits to *S. rhaphiodon* is thus only provisional. However, teeth indistinguishable from those usually named *S. rhaphiodon* occur at Ciply, and the species may therefore be recorded.

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[1] E. Sismonda, Mem. R. Accad. Sci. Torino [2], vol. x. (1849), p. 25.

It seems most probable that the teeth from Ciply described as *Odontaspis* ("*Lamna*") *elegans* by MM. Houzeau, Briart, and Rutot,[1] also pertain to *Scapanorhynchus*. The present writer has only seen the detached dental crowns, and they certainly bear much resemblance to those of the well-known Lower Tertiary species; but these are insufficient to establish as a fact the range of a species of Shark from the Danian to the Lower Miocene. Very similar teeth from France and the United States have also been described under the names of *Lamna Trigeri*[2] and *Lamna texana*.[3] The so-called *Lamna elegans* from the Upper Cretaceous of Scandinavia is proved to be erroneously determined by the circumstance that the inner face of the teeth is smooth.[4]

Odontaspis Bronni, Agassiz.

1843. *Lamna* (*Odontaspis*) *Bronni*, L. Agassiz, Poiss. Foss. vol. iii. p. 297, pl. xxxvii *a*. figs. 8–10.
(?) 1843. *Otodus serratus*, L. Agassiz, *ibid.* p. 272, pl. xxxii. figs. 27, 28.
1852. *Otodus* and *Lamna*, P. Gervais, Zool. et Pal. Franç. pl. lxxvi. figs. 6, 8.
1889. *Odontaspis Bronni*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. i. p. 360.
1890. *Odontaspis acuta*, J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. iv. p. 387, pl. xxxviii. figs. 21–24.

This is a well-characterized species, so far as the dentition is concerned, occurring in the uppermost Cretaceous horizons of France, Holland, and Southern Scandinavia, and abundantly represented in the Lower Danian of Ciply. An allied form also seems to occur in the Oamaru System of New Zealand. The great interest of the species consists in the fact, that its teeth differ very slightly from those of *Odontaspis Rutoti* met with in the Lower Eocene both of Belgium and Kent. It thus affords another instance of the striking similarity existing between the latest Mesozoic and the earliest Tertiary fish-remains.

Odontaspis Houzeaui, sp. nov. Pl. III. Figs. 7, 8.

Teeth with slender, sharply-pointed crown and robust root; outer coronal face flattened, marked with numerous short vertical wrinkles at its base-line, which is more or less arcuate; inner coronal face smooth; a single pair of prominent, slender uncinate lateral denticles, usually with a rudimentary denticle externally; inner nutritive foramen of root not in groove, inconspicuous. Anterior teeth (Fig. 7) exhibiting well-marked sigmoidal curvature, the internal bulging of the root very prominent, and its branches meeting at an obtuse angle; sigmoidal curvature and internal bulging of root also retained in the more posteriorly situated teeth but less conspicuous.

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[1] A. Rutot, "Note sur l'Extension de *Lamna elegans*, Ag., à travers les Terrains Crétacé et Tertiaire, Ann. Soc. Géol. Belg. vol. ii. (1875), p. 35.

[2] H. Coquand, Descript. Géol., etc., Départ. Charente, vol. ii. (1860), p. 98.

[3] F. Roemer, Kreidebild. von Texas (1852), p. 29, pl. i. fig. 7.

[4] J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. iv. (1890), p. 398, pl. xl. figs. 11–17.

The writer has not observed teeth of this form in any collection except that from the "Craie brune" of Ciply, and they are specifically named in honour of their discoverer.

Lamna crassa (Agassiz). Pl. III. Fig. 9.

1843. *Otodus crassus*, L. Agassiz, Poiss. Foss. vol. iii. p. 271, pl. xxxvi. figs. 29–31.
1854. *Otodus crassus*, V. Kiprijanoff, Bull. Soc. Imp. Nat. Moscou, pt. ii. p. 384, pl. ii. figs. 4–20.
1889. *Lamna crassa*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. i. p. 400.

A number of teeth in M. Houzeau's collection are indistinguishable from those of this species, and one fine example is shown of the natural size in Pl. III. Fig. 9. The occurrence of the species in the Lower Danian of Ciply is of some interest, since it is met with only in a much lower horizon (Cenomanian) in the more Eastern areas of Bavaria and Russia.

Corax pristodontus, Agassiz. Pl. III. Figs. 10–16.

1843. *Corax pristodontus*, L. Agassiz, Poiss. Foss. vol. iii. p. 224, pl. xxvi. figs. 9–13.
1889. *Corax pristodontus*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. i. p. 423.

The teeth described as *Corax pristodontus* have long been known to characterize nearly all Upper Senonian and Danian formations; but no discovery of a series of naturally associated teeth seems to have been hitherto recorded. M. Houzeau, however, has now met with fourteen teeth of this form in the "Craie brune phosphatée" of Ciply associated in such a manner as to leave little doubt that they pertained to a single mouth. Seven of the specimens are shown, from the outer aspect, in Pl. III. Figs. 10–16, and it is interesting to observe how constant are the specific characters of the teeth, notwithstanding their variations in shape. The root is large in each, the anterior margin of the crown exhibits its gibbous curvature, and the posterior margin is always either destitute of the notch so characteristic of other species or only feebly excavated.

CHIMÆROIDEI.

Elasmodus Greenoughi, Agassiz. Pl. III. Fig. 17.

1843. *Elasmodus Greenovi*, Sir P. Egerton, Proc. Geol. Soc. vol. iv. p. 156 (name only).
1843. *Elasmodus Greenoughii*, L. Agassiz, Poiss. Foss. vol. iii. p. 350, pl. xl. figs. 11–16.
1891. *Elasmodus Greenoughi*, A. S. Woodward, Catal. Foss. Fishes Brit. Mus. pt. ii. p. 90.

M. Houzeau has discovered in the "Poudingue de la Malogne" several fragmentary teeth of *Elasmodus* agreeing not only in specific characters but also in physical condition with the type specimens of *E. Greenoughi* in the British Museum. The locality and horizon of this species are thus demonstrated for the first time by the new collection, and another genus of fishes common to the Upper Cretaceous and Lower Tertiary is made known. An imperfect left mandibular tooth, wanting the symphysis, is shown of the natural size from the oral aspect in Pl. III. Fig. 17. It exhibits the large punctate median tritor, the prominent laminated anterior outer tritor, and the series of small subdivisions of the posterior outer tritor.

TELEOSTOMI.

Acrotemnus subclavatus (Agassiz).

1844. *Pycnodus subclavatus*, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 198, pl. lxxii *a*. fig. 59.

1887. *Anomœodus subclavatus*, H. Forir, Ann. Soc. Géol. Belg. vol. xiv. p. 25, pl. i. fig. 1.

Numerous detached teeth seem to be referable to this Danian species of Pycnodont, for which we follow Mr. Lydekker[1] in adopting the generic name of *Acrotemnus* (Agassiz), that of *Cœlodus*[2] being preoccupied. When separating the species from *Pycnodus* under a new generic name, Forir overlooked the fact that the Agassizian arrangement of the Pycnodont fishes had been revised about thirty years previously by Heckel. The fine right splenial dentition figured by Forir is, however, an important specimen.

In conclusion, the species from the Lower Danian of Ciply represented in M. Houzeau's collection may be enumerated in a short list. Many more forms could doubtless be recognized if the remains were less fragmentary, and future discoveries of teleostean fishes especially will be awaited with interest.

Elasmobranchii.
Squatina, sp.
Cestracion, sp.
Synechodus, sp.
Scapanorhynchus rhaphiodon (Ag.).
Scapanorhynchus, sp.
Odontaspis Bronni, Ag.
Odontaspis Houzeaui, A. S. Woodw.
Lamna appendiculata (Ag.).
Lamna crassa (Ag.).
Corax pristodontus, Ag.
Corax affinis, Ag.

Chimæroidei.
Elasmodus Greenoughi, Ag.

Ichthyodorulite.
Cœlorhynchus (?) *cretaceus*, Dixon.

Teleostomi.
Acrotemnus subclavatus (Ag.).
Enchodus, sp.

EXPLANATION OF PLATE III.

Fig. 1. *Cestracion Duponti*, Winkler; coronal aspect of lateral tooth, twice natural size. Bruxellian Eocene, Woluwe St. Lambert. [P. 5921.]

Fig. 2. *Lamna verticalis*, Agassiz; tooth, inner (*a*), outer (*b*), and lateral (*c*) aspects. *Ibid.* [P. 5915 *a*.]

Figs. 3, 4. *Pisodus Oweni*, Owen; two detached parasphenoid teeth, coronal (*a*) and lateral (*b*) aspects. *Ibid.* [P. 5924.]

Fig. 5. Ditto; portion of parasphenoid dentition, with detached tooth (*a*) in side view. Bracklesham Beds, Sussex. [38827.]

Fig. 6. *Trigonodon serratus* (Gervais); anterior lateral tooth, inner (*a*) and outer (*b*) aspects. Bruxellian Eocene, Woluwe St. Lambert. [P. 5926 *a*.]

Figs. 7, 8. *Odontaspis Houzeaui*, sp. nov.; two teeth, inner (*a*), outer (*b*), and lateral (*c*) aspects. Lower Danian (Craie brune), Ciply. [P. 5830.]

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[1] Nicholson and Lydekker, Manual Palæont. vol. ii. (1890), p. 984.

[2] J. J. Heckel, Denkschr. k. Akad. Wiss. Wien, vol. xi. (1856), p. 202.

FIG. 9. *Lamna crassa* (Agassiz); tooth, inner (*a*), outer (*b*), and lateral (*c*) aspects. *Ibid.* [P. 5833 *a*.]

FIGS. 10–16. *Corax pristodontus*, Agassiz; associated series of seven teeth, outer aspect. *Ibid.* [P. 5827.]

FIG. 17. *Elasmodus Greenoughi*, Agassiz; imperfect left mandibular tooth, inner aspect. Lower Danian (Poudingue de la Malogne), Ciply. [P. 5837.]

FIG. 18. *Bottosaurus belgicus*, sp. nov.: crown of hinder tooth, coronal (*a*), external or internal (*b*), anterior or posterior (*c*), and inferior (*d*) aspects. Lower Danian (Craie brune), Ciply. [R. 1802.]

Except Fig. 1, all the drawings are of the natural size. The specimens are in the British Museum, and the numbers in square brackets refer to the Register of the Geological Department.

III.—NOTE ON A TOOTH OF AN EXTINCT ALLIGATOR (*BOTTOSAURUS BELGICUS*, sp. nov.) FROM THE LOWER DANIAN OF CIPLY, BELGIUM.

By A. SMITH WOODWARD, F.G.S., F.Z.S.

(PLATE III. FIG. 18.)

AMONG the vertebrate remains discovered by M. Houzeau de Lehaie in the "Craie brune phosphatée" of Ciply, is the crown of a large tritoral tooth, of unusual form and somewhat difficult of determination. A study of the reptilian teeth from the New Jersey Greensand in the Philadelphia Academy of Sciences has, however, suggested to the writer a plausible explanation of the specimen; and a brief notice of its characters may perhaps lead to the discovery of more satisfactory evidence of the animal to which it pertains.

As shown by the figures (Pl. III. Figs. 18*a*–*d*.), which are of the natural size, the tooth is longer than its maximum breadth, tapering at the extremities, without a longitudinal keel, and covered by dense dark enamel, which is nearly smooth, exhibiting only a faint transverse rugosity. One extremity of the crown is more elevated than the other, and the median portion is slightly raised above both these points. At each of the three elevations the surface enamel is worn off, thus exposing the softer light-coloured dentine. In basal view (Fig. 18*d*) the dentine is shown to consist of two or three superposed cones.

There being apparently no piscine dentition with which such a tooth can be compared, it is necessary to refer to the Reptilia; and among these the posterior teeth of the Alligators seem to present the most striking resemblances. In the fossil Alligators of the Lower Tertiaries the short tumid crowns of the hinder teeth are often found detached from the root, while they differ only from the fossil now under discussion in their much smaller size, the absence of lateral eminences, and the presence of at least a short, feeble, longitudinal keel. In a supposed Upper Cretaceous Alligator, however, of which the type species is comparatively large, the posterior teeth agree much more closely both in size and form with the Ciply specimen; and it seems reasonable to predict, from an examination of this fossil, that good evidence of a member of the Alligator-group will eventually be found in the Upper Senonian or Danian of Western Europe. *Bottosaurus*, as the imperfectly known genus in question is termed,[1] has hitherto been met with only in the Upper Cretaceous of the United States; and there is so much agreement between the teeth of the typical *B. Harlani* (Meyer)[2] of the New Jersey Greensand and the tooth now described, that the latter may be provisionally recorded as *Bottosaurus belgicus*. So far as the writer's observations have extended, this is characterized by the presence of a small eminence at each end of the dental crown, and the sharply-rounded—not keeled—form of its median longitudinal line.

IV.—NOTE ON SPECIMENS OF CHERTY SILICEOUS ROCK FROM SOUTH AUSTRALIA.

By GEORGE JENNINGS HINDE, Ph.D., F.G.S.

SOME specimens of Cherty rock forwarded to England for determination some years since by Mr. H. Y. L. Brown, F.G.S., Government Geologist of South Australia, have lately been submitted to me for examination by my friend Dr. H. Woodward, F.R.S., and their structure, as shown in thin sections, seems to me sufficiently interesting to be recorded. The specimens in question are of a light- or yellowish-grey tint, with a waxy lustre, in some portions compact and in others minutely porous, which makes them light to the feel. The rock is hard, scratching glass readily, and there is no reaction with acid. Numerous negative casts of fossils are present in it, the most abundant are those of a foliate Polyzoön probably of the genus *Retepora*, but casts of small turreted Gasteropods and bivalve mollusca are also not uncommon. In all cases the original calcareous tests of these organisms have been dissolved and removed, leaving impressions of their form in the translucent siliceous matrix; in some instances the casts have subsequently been filled up by silica.

Thin microscopic sections of the rock show that minute angular quartz-grains are scattered throughout the cherty matrix, but the principal feature is the occurrence of detached sponge-spicules which in places are heterogeneously crowded together in the rock. These spicules are by no means well preserved; they are mostly fragmentary and in various stages towards dissolution. Where the process has extended furthest, the substance of the spicule has disappeared, and there is either an empty cast, or merely the axial canal of the spicule now infilled with a dark substance. In all parts of the rock-section the former presence of spicules can be detected, although it is only in certain places that the spicules themselves remain in their originally crowded condition. The matrix in which the spicules and quartz-grains are imbedded appears to be mainly of amorphous or opal silica, nearly entirely neutral to polarized light between crossed Nicols, and it is principally in the form of very minute globules or discs usually aggregated together so as to exhibit a microscopic botryoidal appearance, the globules or discs ranging from ·01 to ·03 mm. in diameter. This globular form of opal silica is similar to that which occurs in many of the sponge-beds of the Upper Greensand[1] in this country and there can hardly be any doubt that in this Australian Chert it is due, as in the Chert of this country, to the solution and redeposition of the organic silica of the sponge-spicules.

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[1] L. Agassiz, Proc. Acad. Nat. Sci. Philad. 1849, p. 169.

[2] J. Leidy, Cretaceous Rept. United States (1865), p. 12, pl. iv. figs. 19–23; pl. xviii. figs. 11–14. For further references to *Bottosaurus*, see E. D. Cope, Vert. Cret. Form. West (Rep. U.S. Geol. Surv. Territ. vol. ii. 1875), p. 253.

The spicules in the Australian rock are not sufficiently well preserved to indicate with certainty the sponges to which they belonged; the only forms recognizable are portions of long slender rod-like or acerate spicules from ·5 to 1·4 mm. in length, and ·02 to ·06 in thickness, and calthrop or four-rayed spicules similar to those in the genus *Pachastrella*, O. Sch. It seems probable that they are chiefly of Tetractinellid sponges.

The principal importance of this Chert is the evidence it affords of the origin of this rock in Australia from organic sources; in view of the fact that Chert in Australia has been definitely attributed to chemical deposition[2] merely, the evidence to the contrary is the more valuable.

The specimens were collected by Mr. Brown at Yorke's Peninsula, near Adelaide, and the beds are believed to be of Tertiary age, though, so far as I am aware, their particular horizon has not been ascertained.

V.—Woodwardian Museum Notes.

On Two Abnormal Cretaceous Echinoids.

By T. Roberts, M.A., F.G.S.

In 1887 a quadri-radiate *Echinoconus* (*Galerites*) *subrotundus* from the Lower Chalk of Shudy Camps, Cambridgeshire, was presented to the Woodwardian Museum by J. Carter, Esq., F.G.S. The specimen is in a good state of preservation, but it has been subjected to a slight amount of crushing, and this has caused (1) the apex of the test to be pushed backwards to a very small extent, and (2) an abrasion of the antero-lateral border. It has the subconoidal form of the normal examples of this species, but is subquadrate in section, and this is due to the fact that only four ambulacral and four interambulacral areas are present, the fifth area of both kinds being completely wanting.

Both the ambulacral and interambulacral areas are relatively wider than those in a normal specimen of the same size, and the space of the areas that are wanting appears to be shared proportionately among the eight areas that are present.

The apical disc is compact and roughly rectangular; the outline of the individual plates is not clear, but the disc is seen to be composed of four perforated basals (genitals) and four perforated radials (oculars). Even the basal plate corresponding to the posterior unpaired interambulacral area is perforated, which in normal specimens is imperforate.

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[1] Phil. Trans. vol. clxxv. pt. ii. 1885, p. 428.

[2] Hull and Hardman, Proc. Royal Soc. vol. xlii. (1887), pp. 304–310.

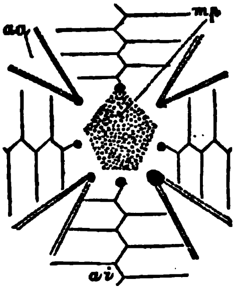
The parts missing from the test are those which lie on the left side of a line drawn through the middle of the anterior single ambulacrum and the posterior unpaired interambulacrum; but it is not possible to ascertain which of the paired areas of this side that are wanting, as the pores in the ambulacral plates round the peristome are indistinctly shown.

Meyer figures[1] an internal cast of *Galerites albogalerus* with six perfect ambulacral areas; but I am not aware of any abnormal example of *Echinoconus subrotundus* having been hitherto described.

Meyer also figures and describes a specimen of *Cidaris coronata*,[2] in which a complete ambulacral and interambulacral area is wanting; but the apical disc is not preserved, and I am unable to find out from his figure and description which of the paired or unpaired areas that were not developed.

In 1881 Prof. Jeffrey Bell described and figured[3] an abnormal specimen of *Amblypneustes formosus*, in which the abactinal surface shows a tetramerous arrangement of parts, but indications of pentamerism are shown on the actinal region. The apical disc, however, is normal, *i.e.* it is composed of ten plates. As in the *Echinoconus* under consideration, it is the left side of the test which has undergone change.

A somewhat similar abnormality, *i.e.* tetramerous abactinal and pentamerous actinal surfaces, has been described[4] by Philippi in *Echinus melo*, but in this case the apical disc was composed of four basals and four radials. Philippi and Bell state[5] that it is the left anterior area which has suffered change; but if the figure is correctly drawn, it is certainly the right posterior paired ambulacral area which has been only partly developed.



Apical disc of *Echinoconus subrotundatus* from Lower Chalk, Shudy Camps.
aa, anti ambulacrum; *mp*, madreporite plate; *ai*, anal interradius.

Mr. F. A. Bather[6] has recently described a tetramerous Crinoid, and he gives references to numerous examples of abnormality amongst the different groups of the Echinodermata.

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[1] Nova Acta Physico-Medica Leop. Car. Acad. 18. 1 (1836), Tab. xiii. figs & 7.

[2] *Ibid.* p. 287, Tab. xiii. figs. 1–5.

[3] Journ. Lin. Soc. (Zoology), vol. xv. (1881), p. 126, pl. v. figs. 1-3.

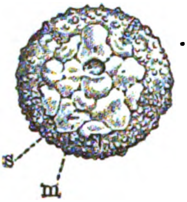
[4] Arch. für Naturges. iii. (1837) p. 241, pl. v.

[5] *Ibid.* p. 242 and *loc. cit.* p. 127.

[6] Q.J.G.S. vol. xlv. p. 149.

In the collection of fossils presented some time ago to the Woodwardian Museum by the late Montagu Smith, Esq., of Trinity College, Cambridge, is rather an interesting specimen of *Peltastes Wrightii*, from the Farringdon Beds of Farringdon. In most of its characters it agrees with the normal examples belonging to this species, but it differs from them in possessing twelve plates in the apical disc. The centro-dorsal plate, five radials, the unpaired and the two left and the right posterior basals are perfectly normal; but the right anterior basal (madreporic) is smaller than any of the other basals, and its genital pore is situated relatively nearer the inner border of the plate than is the case in any other specimen which I have examined. Further, its inner border is somewhat concave, whereas in the ordinary examples it is straight. Interposed between the madreporite plate and the centro-dorsal, and bounded laterally by the left anterior and right posterior basals, is a distinct plate which is roughly

1



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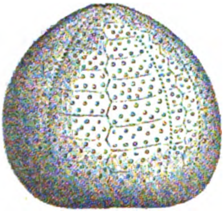

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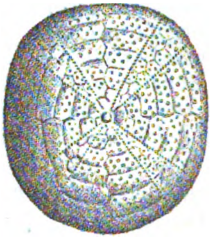

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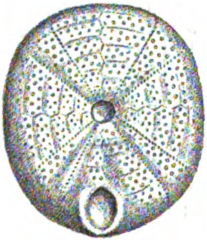

1. *Peltastes Wrightii*, from Greensand, Farringdon. *m*, madreporic plate; *s*, supplementary plate.
2, 3, 4. *Echinoconus subrotundus*, Shudy Camps, Cambridgeshire.

pentagonal in outline. The line separating this additional plate from the madreporite is not one of fracture, but is a true suture-line, and is marked by two pits precisely similar to those which are present on nearly all the suture-lines of the apical disc. In the suture-line between this extra plate and the centro-dorsal there is also a pit, but there are none in the suture-lines between it and the left anterior basal on the one hand, and the right posterior basal on the other. The plate in question is quite distinct from the periproctal plates of the recent *Salenia*, as it is separated from the periproct by the centrodorsal plate.

The relative size and outline of the madreporite plate, and the position of its pore, seem to indicate that the supplementary plate has either been separated from the madreporite plate at some early period of the life of this Echinoid, or that its presence has caused the madreporite plate to take the somewhat modified form described above.

The only abnormal form of *Peltastes Wrightii* which has hitherto been recorded is that which is figured by Wright,[1] where the centro-dorsal plate is stated to be wanting and the apical disc is described[2] as being composed of ten plates. The absence of the centro-dorsal plate in this specimen, however, is due to imperfect preservation, as the notches on the inner edges of the right and left posterior basals[3] abutting against the centro-dorsal clearly prove the former existence of a suture-line with the characteristic pittings; consequently the centro-dorsal plate must have been present at one time, but has since dropped out. Further, the raised rim or border which invariably surrounds the whole of the periproct in the normal specimen, is absent on the anterior half of the periproct in the specimen figured by Wright.

The presence of a centro-dorsal and a supplementary plate in the apical disc of the specimen under consideration, indicate a nearer approach to that of *Acrosalenia* than is shown by the normal examples, although the supplementary plate may not be homologous with any of the supplemental plates in the apical disc of *Acrosalenia*.

VI.—NOTE ON A GREYWETHER AT BAYSWATER.

By HORACE B. WOODWARD, F.G.S.

MY attention was directed last Christmas to the cellar of the King's Head, in Moscow Road, Bayswater. Some enlargement of the premises was required, and the base of the cellar was to be lowered. About a couple of feet beneath the old floor, the workmen came upon a block of stone, which resisted all their efforts to dislodge it: and no wonder! The stone proved to be a huge Greywether, of irregular quadrangular form, measuring 9 ft. 6 in. in length and also in breadth, and as much as 2 ft. 8 in. (possibly more) in thickness. A portion of one side appeared to be a joint-plane; otherwise the mass exhibited the ordinary contours of a concretionary block of sandstone. The rock itself was purely siliceous, and presented the familiar saccharoid aspect of a Wiltshire Greywether. Clean sand was found here and there in hollows on the surface of the stone, tending to prove that it had never been disturbed by human agency. It had evidently found a natural resting-place in the basement-portion of the Thames valley-gravel, close upon its junction with the London Clay; the lowest bed reached in the cellar being "stiff loam." These facts I was enabled to observe under the guidance of Mr. B. J. Capell (architect and surveyor).

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[1] Cret. Echin. pl. xxx. fig. 2.

[2] *Ibid.* p. 151.

[3] I am indebted to Mr. Gregory of the British Museum of Natural History for this information.

In like situations near the base of the river-gravel, Greywethers have been found in many parts of the Thames Valley. Prof. Morris has noted their occurrence near Kew Bridge, and they have been observed at Ealing, in the Brent Valley, in the excavations for the Courts of Justice, and again at Ilford and Grays; but as Mr. Whitaker remarks the blocks occur somewhat rarely.[1] Nowhere else, so far as I am aware, has there been found in the Thames Valley deposits, a block so large as the specimen now discovered at Bayswater.

The transport of the larger blocks met with in the Thames Valley deposits has been attributed by Prof. Prestwich to river-ice, and to floods that imparted a torrential character to the river.[2]

Referring to the Greywethers found at Grays, Prof. Morris thought they "may have been originally derived from the Boulder-clay";[3] and although Mr. Whitaker questions this explanation, there is evidence to show that such blocks were dispersed during the Glacial period over the country north of the Thames.

It is well known that over the Chalk tracts of Buckinghamshire, in the area between Princes Risborough and Beaconsfield, there is a considerable extent of brickearth with unworn flints, Greywethers, and occasionally pudding-stone. The brickearth in some places near Hampden and Bradenham is opened up for the sake of obtaining the stone, which is broken up and shaped into small paving-blocks, largely used at Aylesbury and other places.

This brickearth is very closely associated with the Clay-with-flints, and may be considered to be largely made up of the wreck of Eocene strata commingled with accumulations of Clay-with-flints. Somewhat similar beds occur on the Chalk tracts of the North Downs, to which attention has recently been directed by Professor Prestwich.

In South Buckinghamshire the brickearth in many places is associated with gravel, and this is largely made up of subangular flints (derived chiefly perhaps from subaerial accumulations), together with pebbles of flint from the Eocene beds, and quartzites. These deposits stretch into Hertfordshire, where we find patches of Boulder-clay. In my notes (made when mapping portions of the area in 1869)[4] I stated in reference to the Brickearth and Boulder-clay that one "apparently passes into the other." There is no evidence to suggest that the brickearth and gravel are newer than the main mass of Boulder-clay, but it is possible there may be lenticular masses of Boulder-clay in the brickearths and gravel, as is known to be the case in the neighbourhood of Hertford. Clear sections, however, were wanting in the neighbourhood of St. Albans, where I found it difficult to draw a boundary-line between the brickearth and the occasional remnants of Boulder-clay. In any case the evidence strongly favours the view that the gravels and brickearths (with Greywethers) belong to the Glacial period, and presumably to that portion of it to which the "Middle Glacial" deposits of East Anglia are assigned. Last year I saw at the Ipswich Museum a large block of Hertfordshire pudding-stone, which Dr. J. E. Taylor had procured from the Middle Glacial Sands of that neighbourhood. It was a block measuring 6 feet × 4 feet × 1 foot 4 inches, and weighing about $1\frac{1}{2}$ tons. Floating-ice, in the shape of an iceberg, was, in Dr. Taylor's opinion, the means by which this block had been borne to its place of entombment.

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[1] Whitaker, Geology of London, vol. i. pp. 330, 397, etc.

[2] Phil. Trans. vol. cliv. pt. 2, pp. 289, etc.

[3] Geol. Mag. 1867, p. 64.

[4] See Whitaker, *op. cit.* pp. 288, 289; and Prestwich, Quart. Journ. Geol. Soc. vol. x. pp. 123, etc.

The conclusion suggested by these facts is that, while the pudding-stone and Greywethers originated mainly in the Reading Beds and in the Bagshot Sands, many blocks were incorporated in the Drift during the Glacial period.

To the Glacial deposits, the Thames Valley gravel owes the greater portion of its constituents, the gravel was ready-made, and in pursuing its course and widening its bounds the river ever and anon may have torn away an accumulation in which one of the Greywethers was imbedded. The evidence, however, justifies no positive assertion with regard to the Bayswater Greywether. The nearest remnants of Glacial Drift are six miles distant; and it is quite possible that this particular block may have been derived directly from an outlier of Bagshot Sands, or it may have been left as a relic of Pre-glacial denudation near the spot where it has now been found.

VII.—NOTES ON VOLCANIC PAROXYSMAL EXPLOSIONS, AND THE CAUSES OF VOLCANIC ACTION.[1]

By THOMAS HART, F.G.S.

SINCE visiting the Volcanic region of Central and Southern Italy in the autumn of last year, I have been much exercised from time to time as to some of the conditions which produce, and sustain volcanic activity. It seems to be an undoubted fact that water coming into contact with highly heated rock is one of the most important requisites to produce, and sustain a volcanic eruption. The difficulty has been to explain how water is introduced.

In this connexion I would mention that the principal active volcanoes of the world are in close proximity to coast-lines, as Chimborazo, Vesuvius, or inland areas surrounded by the sea, as Hecla, Etna, and in New Zealand; also in a more special degree in such island groups as the Lipari, Krakatoa.

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[1] Read at the British Association, Section *C* (Geology), Leeds, 1890.

Modern steam-engine boilers are now generally provided with "*Self-acting Injectors*" for supplying them with water in preference to the pumps formerly used, because the former have no working parts, and are not liable to derangement.

In the construction of these Injectors the elastic force of the steam in the boiler is utilized not only to force water into the boiler itself, which it does by imparting to it a considerable velocity, but when required to lift it ten or twenty feet in addition, as from a well.[1] The apparatus may often be seen at work upon most locomotive engines.

I would therefore suggest that this is probably a principle of the conservation of energy which comes into play during volcanic eruptions, the impetuosity of the current from below both carrying the water along with it from fissures in the rocks, and giving rapidity to the slow movement of percolation.

In addition to these forces, as the water ascends the pipe of the volcano, it will sooner or later (according to the pressure) be converted into steam, and produce a *blast* which will assist the upward current of molten rock, ashes, and vapour.

We often have illustrations of this, as when a locomotive discharges glowing ashes through the chimney brought from the furnace by an extra strong blast.

The water may be supplied either by rain percolation, by that of the sea, or by both combined, as well as through natural fissures; or in violent eruptions, through fissures produced by earthquakes which precede or accompany explosive volcanic paroxysms.

It may be well to refer to the account of the great eruption of Vesuvius in A.D. 79, given by Pliny the Younger. He says:—"There had been noticed many days before a *trembling of the earth*, which had caused, however, but little fear, because it is not unusual in Campania. But *that night it was so violent that one thought that everything was being not merely moved, but absolutely overturned.* It was found that the soundings of the Bay were altered,—an effect attributed to the falling masses, but probably in a great measure owing to an elevation of the sea-bed."

Therefore it would appear that the rocks may have been so disturbed by the preceding earthquake as to admit water from the Bay of Naples to the heated rock; and the engine of simple emission set to work that continued with such terrible results.

Further, it appears that water in contact with highly heated rock under enormous pressure may decompose into its elements, and form compounds which produce fuel to greatly intensify that heat.

We have ocular demonstration now in volcanic districts, as at the Solfatara near Naples, also at Vesuvius, that chemical decomposition of the rock below is active, as witnessed by the more or less pungent and complex emanations there given off, and by the beautiful crystals there formed from these various vapours.

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[1] See "Injector," Encyclopædia Britannica, last edition, vol. 22, p. 500; also "Jet Pump," Encyclopædia Britannica, vol. 12, p. 476.

In the address by Mr. Anderson, President of Section G at the British Association Meeting held last year at Newcastle, as to the permanent supply of petroleum, he refers to the theory of Professor Mendelíef that hydrocarbons in large quantities are forming now by the decomposition of metallic carbides through the instrumentality of the elements of water, deep in the bowels of the earth.

REVIEWS.

I.—Catalogue of the Fossil Fishes in the British Museum (Natural History). By Arthur Smith Woodward, F.G.S., F.Z.S. Part II. (1891.)

ONLY two years have passed since the publication of the first part of Mr. A. Smith Woodward's Catalogue of the Fossil Fishes in the British Museum, and now, in an almost incredibly short space of time, we have the second presented to us, a goodly volume of 567 pages and illustrated by sixteen plates. The scientific public, as well as the author, is to be congratulated on the progress of this work, which is calculated not only to be of the greatest value to all curators and keepers of museums in arranging and determining their collections, but to specialists themselves in prosecuting further researches in the same subjects. Mr. Woodward has exhaustively ransacked an immense amount of literature, which his visits to other museums, both British and foreign, have enabled him more thoroughly to appraise. so that as a book of reference the work is simply indispensable to those engaged in the study of fossil ichthyology. But more than this, the author has succeeded in boldly systematizing in a more satisfactory manner than has hitherto been attempted the more advanced notions of classification, which have been floating about in the minds and writings of those engaged in this and cognate studies; and he has done it in such a way as to impress his own individuality on the work.

As regards classification, Mr. Woodward has, as he acknowledges, derived much of his inspiration from Prof. E. D. Cope; but his greater opportunities for making himself acquainted with fossil forms has enabled him advantageously to modify the arrangements suggested by the "somewhat fluctuating" classifications of the American systematist, and some of the ordinal and subordinal terms which he has adopted from that source appear with their scope materially changed. We are not surprised to find our old familiar "Ganoidei" broken up, and the name finally discarded; for this we have long been prepared, and especially since the evidence of the evolutional continuity of the typical Ganoids with the Teleostei showed that the "Palæichthyes" of Günther could not be maintained. Like Cope, Mr. Woodward adopts as subclasses of Pisces the *Elasmobranchii*, *Holocephali*, *Dipnoi*, and *Teleostomi*, to which he adds the *Ostracodermi* (Cope), including the Cephalaspideans and Asterolepids, the former considered by Cope to be Agnatha and therefore not fishes, while the latter were once placed by the same author among the Ascidians, though lately he has pronounced them to be possibly Ostracoderms.

As regards the first four subclasses which possess a demonstrable endoskeleton in the paired limbs, Mr. Woodward has constructed an interesting table to express his view that in the evolution of their members these groups form parallel series. For, as has been pretty well known to palæichthyologists for some time back, the views of Balfour and Mivart that the ordinary Shark-limb is a more archaic and less specialized form than that of *Ceratodus* (archipterygium of Gegenbaur) is directly contradicted by palæontology. As Mr. Woodward well puts it, "If in accordance with the present teaching of embryological research, the paired limbs have been derived from lateral folds, the primitive condition of these appendages still remains undiscovered, and their evolution can only be traced from a comparatively advanced stage. All the most generalized early Palæozoic fishes hitherto met with exhibit two pairs of limbs of the paddle-like form termed archipterygium by Gegenbaur, and subsequent specialization has resulted in the gradual atrophy of these limbs usually with a concomitant development of the fringing dermal rays (actinotrichia)." Recently an interesting attempt has been made by Prof. Anton Fritsch to show that though Gegenbaur is undoubtedly right in holding the modern Shark-limb to be specialized from the archipterygium, yet the archipterygium itself may have been originally developed from a series of parallel rays.[1] And, as observed by Cope, some remains of this ancient fin-fold may possibly be indicated by the two ventral rows of spines in some Devonian Acanthodei.

The present part contains the remainder of the *Elasmobranchii*, the *Holocephali*, the isolated Ichthyodorulites, the *Ostracodermi*, the *Dipnoi*, and a part of the *Teleostomi*, including the Crossopterygii and the Acipenseroid families Palæoniscidæ and Platysomidæ.

ELASMOBRANCHII.

Here Mr. Woodward follows Lütken and Fritsch in including the Acanthodei in this subclass, and as the want of evidence of any opercular apparatus renders it probable that the branchial clefts opened separately on the exterior, this may indeed be the best place to put them in the meanwhile. The remarkable deviation from the ordinary Elasmobranch type, exhibited by their paired fins, the author explains as due to extreme specialization (abbreviation) and his idea is that the Acanthodians "occupy the same position in the Elasmobranch phylum that is held at the present day by the Actinopterygians in that of Teleostomi." The account given of this group is one of the most interesting sections of the book, and he gives an original restoration of *Acanthodes Wardi*, Eg., which is a considerable improvement on the old and well-known figures of Roemer and Lütken (*A. Bronni*), though the orbit is too small, the peculiar fringe-like contour of the ventral fin is not given, and I am also inclined to hold that in representing the fish with prominent branchial "frills" after the manner of the recent *Chlamydoselache* the author is going beyond the legitimate limits of "restoration." The limitation of the family term *Acanthodidæ* to those genera with one dorsal fin and spine is quite right, but I am not so certain that making two separate families *Ischnacanthidæ* and *Diplacanthidæ* out of those with two is equally justifiable. The only difference which Mr. Woodward gives between these two supposed families is the absence of "clavicular" bones in the former and their presence in the latter, and I, for one, am at present perfectly convinced that the element which he calls "clavicle" in *Diplacanthus* is identical with that which he considers as "basal cartilage" in *Acanthodes* and *Ischnacanthus*. It seems also somewhat inconsistent, that he should give in his definition of *Diplacanthus* "a pair of free spines situated between the pectoral and pelvic fins," while he persists in rejecting the genus *Mesacanthus*, which is distinguished from *Acanthodes* by the possession of that identical character!

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[1] "Fauna der Gaskohle," vol. iii. pt. i. pp. 44.

HOLOCEPHALI.

Next come the Holocephali with the single order Chimæroidei, which is divided into the four families of Ptyctodontidæ, Squaloraiidæ, Myriacanthidæ, and Chimæridæ. After these have been treated of we have a section upon the isolated Ichthyodorulites, some of which appertained, no doubt, to Chimæroids as well as to Elasmobranchs.

OSTRACODERMI.

We now enter a group of problematical organisms, concerning whose position, the analogy of recent forms affords us comparatively little clue; these are the *Cephalaspides* of Agassiz, *minus* the Coccosteans. The Coccosteans and Asterolepids were removed by M'Coy from Agassiz's Cephalaspides to form the order Placodermata, the remainder were divided by Lankester into two well-marked though allied groups, the Heterostraci and Osteostraci, exemplified by *Pteraspis* and *Cephalaspis* respectively. These two groups form the Ostracodermi of Cope, who considered them to be Agnatha, as no remains of lower jaw had been discovered in them; latterly he hinted that the Asterolepids which he had previously assigned to the Ascidians, as a group termed Antiarcha, might also belong here. This is the grouping now adopted by Mr. Woodward, but he takes the additional step of replacing these creatures among the fishes, justly remarking, "That there were no hard parts around the mouth and in relation to paired appendages capable of being preserved under ordinary conditions of fossilization seems to be satisfactorily demonstrated; but there is no justification for any further statement that jaws, pectoral and pelvic arches were absent." And certainly it seems difficult for any one to take into consideration the fact that the plates of *Pterichthys* are made of true bone, to look at its system of lateral sense-canals, as well as its scaly tail and fins, and yet to doubt that it is really a fish. Mr. Woodward's comparison of the structure of the Asterolepids and Ostracostei is of great interest, pointing out, as he does, the similarity of the position of the orbits and of the interorbital pineal plate, the resemblance of the scaly tail of *Pterichthys* to that of *Cephalaspis*, while he at the same time finds an analogy between the ventral shields of some genera (*Didymaspis*, *Tremataspis*) and the ventral plates of *Pterichthys.*

In plates v. and vi. figures of the British species of *Pterichthys* are given, which are a great improvement on the old figures of Agassiz. In plate v. fig. 10, however, the central plate of the lower arm is lettered "anconeal," and a portion of the terminal one "central," the same mistake occurring also in pl. vi. fig. 4.

DIPNOI.

The Dipnoi are made to include two orders, Sirenoidei and Arthrodira. The Sirenoids, which are characterized by their archipterygial paired fins, and bodies covered with imbricating scales, are divided into the four families of Dipteridæ, Phaneropleuridæ, Ctenodontidæ, and Lepidosirenidæ; but this arrangement leaves room for revision, as *Uronemus* cannot be included in the Phaneropleuridæ, however much it resembles *Phaneropleuron* in external shape. Under Ctenodontidæ a somewhat serious error occurs in connexion with the description of a fine cranial shield of *Ctenodus cristatus*, which is also beautifully figured in plate iv. Here Mr. Woodward states (p. 253) that "the median series of bones is arranged exactly as in *Acipenser* and *Polyodon*." The arrangement does indeed resemble that in *Acipenser*, but *not* in *Polyodon*, in which there is no large median plate at the back of the shield, but two plates corresponding to the parietals of Palæoniscidæ and Chondrosteidæ, and like them being in contact in the middle line. Another mistake occurs on p. 234, in which, referring to what he gives as the "upper dental plates" of the same species (fig. 36, No. 2), he says that they are "somewhat inaccurately drawn, the oral aspect being in reality concave." But the fact is that they are quite accurately drawn, but unfortunately represent the *lower* and *not* the upper dental plates of the species in question. It is, however, fair to state that this error originated with the late Messrs. Hancock and Atthey, from one of whose plates the figure in question is copied.[1]

Coccosteus and its allies Mr. Woodward boldly places in the Dipnoi, where they form the order of Arthrodira, which he considers to bear "the same relation to the Sirenoidei that the Acanthodians seem to hold with respect to the primitive Elasmobranchs (Ichthyotomi) or the Actinopterygians with respect to the primitive Teleostomes (Crossopterygii)." This is an attractive solution of the question which has often been hinted at since the discovery of *Dinichthys* and its *Lepidosiren*-like teeth by Prof. Newberry. It may be so, and though I myself am one of those who have entertained the idea,[2] I scarcely feel yet that the matter is sufficiently ripe for definitely raising the Arthrodira beyond the rank of "*incertæ sedis.*" It may be that they were autostylic, as Mr. Woodward thinks is so probable; but the absence of an osseous hyomandibular is no sure evidence that it did not exist in a cartilaginous condition. An important discovery is that of basal elements of a ventral fin in *Coccosteus*, which does not seem to have been archipterygial, but abbreviate, and though this in the minds of some would militate against these forms being classified with the Dipnoi, it is in accordance with Mr. Woodward's theory of their evolutional relationship to the Sirenoidei. It is satisfactory that the author gives no countenance to Prof. von Koenen's idea that a pectoral limb may yet be discovered in *Coccosteus decipiens*.

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[1] Ann. and Mag. Nat. Hist. [4], vol. vii. pl. xiv.

[2] "It seems therefore not unlikely that the *Placodermata* will eventually turn out to have been an aberrant group of loricated Dipnoi."—R. H. Traquair, in Proc. Roy. Phys. Soc. Edinburgh, vol. v. p. 159 (1879–80).

TELEOSTOMI—CROSSOPTERYGII.

Mr. Woodward subdivides the Teleostomi into Crossopterygii and Actinopterygii; the former including the Rhipidopterygii of Cope, the latter the Podopterygii of the same author.

The Crossopterygii are divided into Haplistia, Rhipidistia, Actinistia and Cladistia. The Haplistia are not however the Haplistia of Cope, who established the order for the Dipnoan *Phaneropleuron*, for instead of it we have the problematical Tarrasiidæ, whose relationship to the Crossopterygii I have myself indicated in a recent paper, though I am far from believing that the question of its position is in any way settled, and indeed Mr. Woodward only places *Tarrasius* here provisionally. It certainly has an obtusely lobate pectoral fin, which I had the pleasure of pointing out to Mr. Woodward during a visit which he paid to Edinburgh in the spring of last year.

In the Rhipidistia Cope included only the Rhizodont genus *Tristichopterus*, which was thus removed from its own family, the other members of which he joined with the Holoptychiidæ and Osteolepidæ into another order, that of the Taxistia. Very properly Mr. Woodward fuses those two orders, for which he adopts the name Rhipidistia, containing the families Holoptychiidæ, Rhizodontidæ, Osteolepidæ and Onychodontidæ. This is indeed a natural group, for though the Holoptychii differ in some salient points from the other families here associated with them, they are also bound to them by obvious points of similarity which cannot be overlooked. Mr. Woodward adopts the view which I have so repeatedly maintained, that the Dendrodonts and Holoptychians are one and the same thing; but he does not clearly express the difference between the Dendrodont and Rhizodont type of tooth structure. Also when he says that in the Rhizodontidæ the vertical infoldings of the walls of the teeth are "comparatively few and simple," and in the Osteolepidæ only slightly infolded at the base, surely he cannot have examined sections of the base of the teeth in the larger genera of both families, such as *Rhizodus* or *Megalichthys*, in which, simple though the folds may be at the commencement of the external fluting, as they pass down to the root of the tooth they assume a complexity which, especially in *Rhizodus*, is absolutely wonderful as well as beautiful, though the vertical tubes formed by this infolding never form an interlacing network as in the Dendrodont type.

In the family Onychodontidæ is included the singular genus *Onychodus*, in which a scroll-like symphysial tooth-bearing element is present, and concerning which it is much to be desired that further details may soon be discovered.

The Actinistia (Cope) include the single family of Cœlacanthidæ, of which a concise account is given. Under Cladistia (Cope) we have the recent family of Polypteridæ, as yet unknown in a fossil state. Certainly *Polypterus* differs in many salient points from the known fossil Crossopterygii, and, as Mr. Woodward remarks, "The di- or tri-basal character of the pectoral fins in conjunction with other features may perhaps justify the recognition of this group as a distinct order."

ACTINOPTERYGII.

Under "Chondrostei" our author includes the Podopterygii of Cope (Acipenseridæ, Polyodontidæ, Chondrosteidæ), *plus* the Palæoniscidæ, Platysomidæ, Catopteridæ, and Belonorhynchidæ.

It is certainly satisfactory to myself that Mr. Woodward has adopted the placing of the Palæoniscidæ and Platysomidæ with the Sturgeons, which, since I proposed it in 1877,[1] has hitherto for the most part been either opposed or ignored. In his conception of the group, however, he does not place much stress on the peculiar heterocercy of the tail, but more on the excess in number of the dermal rays of the median fins over that of their supporting ossicles (baseosts), and hence he admits into it the semiheterocercal *Catopteridæ*, and the abbreviate-diphycercal *Belonorhynchidæ*, previously considered to belong rather to the Lepidostoid series. Certainly the Palæoniscus-like aspect of the dorsal and anal fins of *Catopterus* is extreme. In the brief definition of the Polyodontidæ, p. 424, he gives as a character that the cranial shield has a "median azygous series of bones," but I have already under Dipnoi pointed out that there is no median plate at the back of the skull in *Polyodon*, as in *Acipenser*, though further on, between the frontals, there commences a longitudinal series of four small ones extending to the extremity of the paddle-like snout, and which doubtless represent the single large median super-ethmoid of *Palæoniscus*.

In treating of the Palæoniscidæ the author gives a useful synopsis of the genera comprised in this extensive family, which he describes as "a provisional attempt to follow the lines of evolution." I quite agree with him that the obliquity of the suspensorium is a mark of specialization, and that such genera as *Canobius* and *Eurylepis* are in this respect more primitive than others such as *Cheirolepis* or *Pygopterus*, in which it is extremely oblique. So likewise is the tendency of the scales to pass from the rhombic to a circular and deeply imbricated form, as in *Cryphiolepis* and *Coccolepis*; in fact the scales of the former genus become so nearly absolutely cycloidal that when I first came upon them I referred them to *Cœlacanthus*. In a similar light is to be viewed the degeneracy of the squamation in *Phanerosteon*, in which the scales over the greater part of the body absolutely disappear; but whether the more advanced position of the dorsal fin in some cases than in others is also to be considered as a mark of specialization requires further consideration.

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[1] "Carboniferous Fishes" (Mon. Palæont. Soc.).

The Platysomidæ, which Mr. Woodward calls "Platysomatidæ" finish the volume, and are handled with the same care which characterizes the whole of the work. Of *Dorypterus* the author remarks that it is "here regarded as a highly specialized ally of the family destitute of squamation on the flanks." In this he is undoubtedly right, but it is much to be regretted that, owing to the great rarity of this remarkable fish, nothing definite is as yet known of its cranial structure.

It would be impossible within the limits of a review to enter into questions as to the retention or rejection of various genera and species. As regards the fishes of the Scotch Old Red Sandstone I am, however, pleased to find that Mr. Woodward acquiesces in the extensive slaughter of pseudo-species which I proposed in this MAGAZINE a little more than two years ago. These and other things too can only be discussed by the writers of future memoirs dealing specially with the matters concerned.

A word now as to nomenclature. I am sorry to see that Mr. Woodward adheres to the present fashionable craze of writing all specific names with a small initial letter, even when they represent the names of persons. It is really no compliment to any one to have a species called after him, if he is to find his name spelt in so grotesque a fashion.

Mr. Woodward, instead of the classically correct, but decidedly cacophonic "Osteolepididæ" and "Asterolepididæ," uses "Osteolepidæ" and "Asterolepidæ"—"from the point of view of euphony." Why then, instead of "Platysomidæ," does he write "Platysomatidæ," which sounds nearly equally badly, while the change seems to me more than wholly uncalled for? It is true that *σωμα*, a body, has for its genitive *σωματος*, but the name of the type genus of this family is not "*Platysoma*" but *Platysomus*, and though Agassiz in compounding this name used two Greek words, the latter of which was a neuter substantive, he made out of them, as he was quite entitled to do, a new Latin masculine word, and therefore "Platysomidæ" is perfectly correct.

On the same principle I devised some new generic names such as *Microbrachius*, *Euctenius*, *Cynopodius*, and I am curious to know why Mr. Woodward has altered the first of these into "*Microbrachium.*" If it is because the Latin for "arm" is *brachium* and the Greek *βραχιων*, then surely to be consistent he ought to write not only *Platysoma*, but also *Gyracantha*, *Graphiura* and *Amblypterum!* for certainly in my Greek dictionary the words for *thorn*, *tail*, and *wing*, respectively, are *ἡ ἄκανθα*, *ἡ οὖρα*, and *τό πτερόν*.

The sixteen lithographic plates are from the accomplished pencil of Miss G. M. Woodward, and it is impossible to speak in too high terms of their excellence as well as works of art as illustrations of scientific fact.

R. H. TRAQUAIR.

II.—NOTES ON THE GEOLOGY OF AYRSHIRE. By JAMES LINDSAY, M.A., B.D., B.Sc., F.G.S. 8vo. pp. 31. (Glasgow, 1890.)

IN this pamphlet the author gives a summary of what is known about the geology of Ayrshire, and points out many leading facts that are of general geological interest and significance. Prof. Lapworth's researches on the Girvan rocks naturally claim especial attention, and the various fossiliferous stages in these Ordovician and Silurian rocks are duly noted. The Ballantrae rocks have yielded a Graptolitic fauna believed to be of Arenig age, but many of the rocks so grouped may be of earlier age. Above them come the Girvan rocks ranging from Llandeilo-Bala to Wenlock, while rocks probably belonging to the Ludlow Series are also noticed. The Lower Old Red Sandstone yielding *Cephalaspis Lyelli*, and the Upper beds with *Holoptychius* and *Pterichthys*, are represented in Ayrshire; but the beds on the whole contrast strongly in their comparatively barren character with the older fossiliferous rocks. The author (quoting Dr. A. Geikie) mentions the occurrence in the heart of the Old Red Sandstone series of Arran, of marine limestone-bands containing Carboniferous Limestone fossils; thus proving that prior to the termination of the Upper Old Red Sandstone, the fauna of that Limestone already existed outside the area. Nevertheless we find a development of Calciferous Sandstones at the base of the Carboniferous Limestone; and this Limestone is represented with lower, middle, and upper divisions, underlying the Coal-measures. The lower limestone swells out to 100 feet thick, and is the most massive bed of limestone in any part of the Scottish Carboniferous system. The leading fossils of the divisions are mentioned, and in the central portion come the black-band ironstone and some coal-seams.

The Permian strata, the Volcanic rocks, and the Drift accumulations also receive due attention. Thus we may commend this little work to all who seek acquaintance with the geology of Ayrshire.

III.—CONTRIBUTIONS TO THE TERTIARY FAUNA OF FLORIDA, WITH ESPECIAL REFERENCE TO THE MIOCENE SILEX-BEDS OF TAMPA, AND THE PLIOCENE BEDS OF THE CALOOSAHATCHIE RIVER. Part I. By W. H. DALL, A.M. (Trans. Wagner Free Inst. of Sc. of Philadelphia, Vol. III. (1890), pp. 1–178, 12 plates.)

THIS memoir deals almost exclusively with the Pulmonate, Opisthobranchiate and Orthodont Gasteropods of the Upper Tertiaries of Florida. The author states that he hopes it "will make a beginning in the direction of a better and more natural classification of our (American) Tertiary molluscs, and of a clearance of the ground of synonyms, erroneous identifications, and other misconceptions." Mr. Dall's knowledge of recent and fossil Gasteropods, not only of the American continent, but of Europe and other parts of the world, has been of immense service to him in dealing with the present subject, as is evinced by the astute criticisms with which the memoir is enriched.

The greatest interest, perhaps, centres round the *Volutidæ*, where the origin of the columellar plications, their obliquity, number and form, and the characters of the nuclei are set forth at great length; forming a most important contribution to our knowledge of the morphology of this group, and which cannot fail to become classical material. The author states: "The indications are pretty clear that from the Mesozoic *Fusidæ* are descended, on the one hand *Tudicla*, *Fulgur*, *Fasciolaria*, and *Latirus*; and on the other *Volutomorpha*, *Volutoderma*, *Volutilithes*, *Lyria*, *Voluta*, *Caricella*, *Scaphella*, *Aurinia*, *Turbinella* proper and *Vasum*."

Considering the extensive range of the monograph, there are very few slips. We may point out, however, that the sub-genus *Subularia*, Monterosato. 1884, should be substituted for *Leiostraca*, H. and A. Adams, 1853 (*non* Albers, 1850). The genus *Tritonium*, Link, 1807, should disappear, that name having previously been employed by Müller, 1776, for a different mollusc; whilst *Nassaria*, Link, 1807, *fide* H. and A. Adams, 1853 (*non* Duméril, 1806), should be replaced by *Hindsia*, Adams, 1850.

Ancillaria, Lamarck, 1810, is synonymous with *Ancilla*, Lamarck, 1799, and the latter name should therefore be preferred. *Tornatina*, Adams, 1850, should take the place of *Utriculus*, Brown, 1845 (*non* Schumacher, 1817). The name *Polygyra cereolus microdonta*, Dall, is barely in accordance with the rules of nomenclature.

The author is, notwithstanding, to be sincerely congratulated on the production of a monograph of such unquestionable value, the like of which has certainly never before appeared in the United States. We anxiously await the publication of Part II., which will contain descriptions of the remainder of the Gasteropoda, the Scaphopoda and the bivalves. G. F. H.

IV.—THE AUTOBIOGRAPHY OF THE EARTH. By REV. H. N. HUTCHINSON, B.A., F.G.S. Small 8vo. pp. 290. (London, Edward Stanford, 1890.)

THIS little volume is a popular exposition of geology intended for the use of general readers, to whom ordinary text-books are "dry, uninteresting, and even quite unintelligible." Within the space of 300 pages all the principal features both of physiography and stratigraphy are discussed, beginning with the nebular theory and terminating with the advent of man; and, notwithstanding the brevity and condensation which the treatment of so vast a subject in such limited space entails, Mr. Hutchinson is to be congratulated on the manner in which he succeeds in converting bare statements of fact and theory into pleasant and entertaining gossip. One leading feature of the book is the care bestowed by the author in explaining the methods by which many of the broad conclusions of the geologist have been attained; while another feature tending to popularize the subject and render it intelligible is the manner in which the operations of the various geological agents are treated successively amid stratigraphical considerations, as the different rock-structures requiring explanation are encountered.

It is difficult for one accustomed to the literature of geology and palæontology to judge how far the present volume will meet the popular demand; but we are inclined to think that in some cases the use of imperfectly defined technical terms and expressions will present difficulties to the general reader. The occasional indiscriminate use of synonymous terms (*e.g.* Carboniferous Limestone and Mountain Limestone) without explanation also seems unfortunate; and it would be well to attend to these points in a subsequent edition. On the other hand, for a compilation extending over so wide a field the work before us is remarkably free from errors, and all the mistakes worthy of note seem to be confined to palæontological and zoological subjects. Brachiopods and Polyzoa are very far from being Mollusca, as the author regards them; and the origin of the name "Foraminifera" is inaccurately stated on p. 98. The Devonian "dicotyledon" (p. 86) admits of a more reasonable interpretation than that originally suggested by Sir William Dawson; and the Carboniferous fruit "migonocarpon" ought to be "trigonocarpon." Several Brachiopods are mentioned on p. 96 as if they were Corals; and the first appearance of "Sharks," as generally understood, is not in the Jurassic (p. 204), but in the Upper Silurian. European Cretaceous Mosasaurs are more numerous than the author supposes (p. 235); and the Eocene Snake, *Palæophis*, is far from being a Boa-constrictor (p. 242). There are also several misprints, such as *Hyperodopedon* for *Hyperodapedon*, *Notosaurus* for *Nothosaurus*, *Simoliophis* for *Cimoliophis*, and *Unitatherium* for *Uintatherium*. These, however, are small matters, and we only call attention to them in view of a second edition, which ought soon to be required. As a reliable and entertaining introduction to the subject of which it treats, the work is a valuable addition to popular scientific literature.

V.—A BIBLIOGRAPHY OF PALÆOZOIC CRUSTACEA FROM 1698 TO 1889, INCLUDING A LIST OF NORTH AMERICAN SPECIES AND A SYSTEMATIC ARRANGEMENT OF GENERA. By A. W. VOGDES. 8vo. pp. 177. Washington (U. S. Geol. Survey, Bull. No. 63, 1890).

MR. VOGDES' carefully compiled Bibliography and Catalogues of Palæozoic Crustacea are doubly welcome, when we remember the extraordinary carelessness of compilation and abundance of misprints in some recent publications of a similar nature which have reached us from America. Mr. Vogdes not only shows an intimate knowledge of his subject, but also his perfect competence to refer to a book accurately and fully. The whole work, indeed, bears evidence of a careful and painstaking endeavour to produce the best results possible, instead of a hasty scramble through such books as are to be found in the library of a minor town, and wholesale misquotations from others which the compiler has never seen and does not trouble to find.

There are very few misprints, and in reading his proofs Mr. Vogdes has had the assistance of Prof. U. P. James. The references are full; there is no irritating series of initial letters used in quotation: thus no doubt can be entertained as to the work referred to.

The Bibliography occupies the first 78 pages, the Catalogue of Trilobites from pp. 81–148, and the Catalogue of Palæozoic non-Trilobites [unfortunate word] pp. 151–177, a brief appendix of seven pages being included with the author's edition.

This Bibliography will be exceedingly valuable, and will, with the Catalogues, considerably lighten the labours of those who work in Palæozoic Crustacea and Arachnida.

It would be ungenerous to find fault with so careful a work, but we may perhaps be permitted to refer to two points in the hope that Mr. Vogdes will consider them in his second edition. In the first place, when a species is referred to more than once, it seems desirable, instead of reprinting the name itself, to substitute a ———, and at the same time to represent the name of the original author in a similar manner. There could then be no doubt as to whether or no the same specific name had been used by two authors for different forms. Take for instance *Leperditia alta*, Conrad sp. Five authors have referred to *alta*, and though the specialist may know there is only one *L. alta*, doubt cannot fail to oppress the mind of the novice. It would be absolutely clear if three dashes, representing respectively generic, trivial, and authors' names, were used before the name of the authors referring to the particular species, thus ——— ——— —— Vogdes, Bibl. 'Pal. Crust., etc. In the second place, it would have been better had Mr. Vogdes enumerated separately the new generic and specific names that he has suggested in his Catalogue, as in a work of this kind they are especially liable to be overlooked. C. D. S.

VI.—ON AN ERECT TREE-STUMP WITH ROOTS, FROM THE COAL OF PIESBERG, NEAR OSNABRÜCK. By H. POTONIÉ.

DER IM LICHTHOF DER KÖNIGL. GEOLOGISCHEN LANDESANSTALT UND BERGAKADEMIE AUFGESTELLTE BAUMSTUMPF MIT WURZELN AUS DEM CARBON DES PIESBERGES. VON HERRN H. POTONIÉ. [Jahrbuch der Königl. preuss. geologischen Landesanstalt, 1889, s. 246.]

THE "tree stump with roots" which forms the subject of the present notice was found in the Piesberg Colliery near Osnabrück standing in its natural position at right angles to the plane of the bedding.

Several specimens have been found in the same locality. Of the two largest specimens one is now in the Osnabrück Museum, the other, described in detail by Potonié, in the Berlin Bergakademie.

The latter specimen is displayed to advantage in the Berlin Museum, as one sees from the excellent photograph in Potonié's paper, and reminds one of the giant *Stigmaria* recently added to the Owens College Museum, Manchester. In the Berlin *Stigmaria* there is much more of the stem preserved than in the Manchester example; in neither specimen can one determine to what species the tree should be referred, nor indeed with any certainty fix the genus, whether *Lepidodendron* or *Sigillaria*. From such surface markings as are preserved on the roots Potonié names the Stigmarian portion *Stigmaria ficoides* (Brong.), var. *inæqualis* (Göpp.)

In the Berlin specimen the height of the tree stump, measured from the first dichotomy of the root, is 1·30 metres (4·26 feet). In the famous Dixon Fold fossils, casts of which are preserved in the Manchester Museum, the stem measures in one case 2ft. 6in., in the other 6ft. 6in.[1]

To compare the roots. In the Clayton specimen (Owens College Museum) the roots attain a greater length than in the Berlin specimen: in both cases the several subdivisions of the dichotomous branches are fairly uniform in size, in the latter specimen the longest terminal root branch measures 2·20 metres (7·21ft.), in the former the longest ultimate branch has a length of 12ft. 8in. Potonié compares the dichotomous branching of *Stigmaria* to that of *Isoetes*. Photographs are given of such portions of the stem where the carbonaceous covering shows any surface-markings; these occur in the form of more or less spirally arranged spindle-shaped prominences, which represent the points of exit of the primary medullary rays from the wood into the cortex.

Attention is called to a well-marked longitudinal striation ("Langsstreifung") on the surface of the carbonaceous layer; this is regarded by Potonié as the expression of the elongated elements of the wood. For this striation, which is seen not infrequently on decorticated *Lepidodendra* and *Sigillariæ*, the term "Holzstreifung" is proposed.

A. C. SEWARD.

VII.—THE MALTESE ISLANDS, WITH SPECIAL REFERENCE TO THEIR GEOLOGICAL STRUCTURE. By JOHN MURRAY, LL.D., F.R.S., F.R.S.E. Scottish Geographical Magazine, September, 1890, Geological Map and Sections, Two Plates and Woodcuts.

THE Scottish Geographical Magazine is fast becoming one of the most important geological serials published in this kingdom. This paper by Dr. Murray is only one of many valuable contributions to geology which have been published in its pages. The Geology of Malta was sadly in need of some one to collect together the previous observations of others, and to add those of practical experience. Dr. Murray has done this work well, and by appending a fairly complete bibliography has earned the thanks of all geologists, as well as those of the student of deep-sea deposits. The first eleven pages (pp. 449–459) of the paper are occupied with a brief history of the islands (Malta, Gogo, Comino, Cominotto, and Filfola), geographical, climatal, botanical, zoological, historical, and economic; the remaining pages (459–488) are devoted to the geology and marine deposits off the coasts. The rocks are all of Tertiary age, and have been variously classed as Eocene, Oligocene, and Miocene by different observers. About 1150 feet of strata are exposed, each of which yields an interesting fauna, while numerous remains of the later inhabitants of the islands are found in the fissures which exist in various localities. The deposits are treated in order, and appended to each is an important and full list of the Foraminifera, the most abundant organisms in the rocks, supplied by Frederick Pearcey. These lists are exceedingly interesting in connexion with the recent Foraminiferal fauna of the Mediterranean. Analyses of the different rocks are given, and the probable depth of water in which they were deposited is discussed. Remarks on the economic value of the rocks as building material, and interesting notes of a practical nature in addition to this subject, are supplied by C. H. Colson. The various caves that have yielded vertebrate remains are catalogued, and the paper closes with a description of the recent marine deposits in process of formation off Malta, and a long discussion as to the origin of the rocks and soils. The plates contain representations of four slices of Foraminiferal Limestones from Malta. The map and sections are in every way excellent, and a copy of these has been framed and hung up in the Fossil Mammalian Gallery of the Natural History Museum, close to Admiral Spratt's, and Dr. Leith Adam's Collections of Pigmy Elephant-remains from Malta, and forms one of many such valuable aids to the student in the Palæontological Department. C. D. S.

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[1] A monograph on the Morphology and Histology of *Stigmaria Ficoides* by W. C. Williamson, LL.D., F.R.S. (Palæontographical Soc. vol. for 1886, London).

REPORTS AND PROCEEDINGS.

Linnæan Society.

Jan. 15, 1891.—Dr. P. H. Carpenter, F.R.S., read a paper on "Some Points in the Morphology of the Cystidea."

A large number of the Cystidea may be compared with dicyclic Crinoidea more directly than has hitherto been supposed.

Group I. has a generally six-rayed structure; Exx. *Caryocrinus, Hemicosmites, Juglandocrinus, Cordylocrinus.* Here are three circlets of plates, viz. four infrabasals, two of which are double plates, six basals, and six radials, with two or three interradials enclosed within the radial circlet. The summit-plates or orals also are comparable with those of Crinoidea, though differing in number; thus *Caryocrinus* has one central plate and five others around it, corresponding to the one central and four surrounding plates of a Crinoid: the central plate in either case represents the posterior oral. Even the number is sometimes the same as in a Crinoid; thus, though *Caryocystis granatum* has six rays, *C. testudinarius* (v. Buch. *non* His.) has five; while there are but four in other species.

Group II. has a five-rayed structure; Exx. *Lepadocrinus, Apiocystis, Prunocystis, Echinoencrinus* (Forbes *non* v. Meyer). Here are four infrabasals, one of which is double, five basals, five radials and five interradials (?). Sometimes an interradial is missing, e.g. *Cystoblastus* (l. post.), *Pseudocrinus* (r. antr.). Some genera (*Apiocystis, Callocystis*) have only four ambulacra. The plates in this group may still be designated by the numbers applied to them by Forbes: thus 1–4 are infrabasals, 5–9 basals, 10–14 radials, 15–18 or 19 interradials. The homology of Nos. 10–14 with radials is corroborated by *Cystoblastus*, in which these five plates have a deep fissure for the ambulacra. There is moreover symmetry in the disposition of the pore-rhombs, which generally occur on plates 1 & 5, 14 & 15, 12 & 18.

Variations from the simple types occur. Sometimes two of the radials sink into the basal circlet, e.g. *Callocystis*, while in *Glyptocystis* and *Cystoblastus* some or all of the interradials enter the radial ring. *Glyptocystis* affords a transition to such flattened forms as *Pleurocystis*. *Homocystis*, *Lichenoides*, *Macrocystella* and some other types have three regularly alternating series of plates.

Orals, homologous with those of Crinoidea, are to be distinguished: (*a*) five of equal size, e.g. *Cyathocystis* of Russia; (*β*) five of unequal size, the posterior being the larger, e.g. *Glyptosphæra Leuchtenbergi* and *Sphæronis*; (*γ*) none in adult, probably resorbed, e.g. *Ascocystis*, *Pirocystis*, *Cryptocrinus*.

The apertures on the summit are as follows:—1. Central = Mouth; 2. Large lateral = Anus; 3. In the anal interradius between mouth and anus, sometimes close to the anus, sometimes even in the same genus (e.g. *Aristocystis*), further from it, = Genital aperture; in some cases this is contained in the anal aperture as in the recent starfish *Hymenaster* and *Pythonaster*; 4. A small opening by the side of the genital = Excretory aperture; this is seen in *Aristocystis*, and, as a "madreporic plate," in *Glyptosphæra*. In *Echinoencrinus* it is not so much in the anal interradius (C D) as in the next one (D E), and the single opening occupying this position in *Cystoblastus*, *Glyptocystis*, and other types, is probably of the same nature.

GEOLOGICAL SOCIETY OF LONDON.

I.—January 21, 1891.—A. Geikie, Esq., LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Age, Formation, and Successive Drift Stages of the Valley of the Darent; with Remarks on the Palæolithic Implements of the District, and on the Origin of the Chalk Escarpment." By Professor Joseph Prestwich, D.C.L., F.R.S., F.G.S., etc.

i. *General Character and Age of the Darent Valley.*—The river is formed by the union of two streams, the main one flowing east from near Limpsfield, the other west from near Ightham, parallel with the ranges of Lower Greensand and Chalk, and flows northward into the Thames. The first indent of the valley was subsequent to the deposition of the Lenham Sands, and indeed to the Red Clay with flints and the old implement-bearing drift with which this is associated; and the same remark applies to a system of smaller valleys starting near the crest of the escarpment and running into the Thames.

ii. *The Chalk Plateau Drifts and associated Flint Implements.*—Since the publication of the author's Ightham paper, Mr. Harrison and Mr. De B. Crawshay have found implements mostly of rude type (though a few are as well finished as those of Abbeville) in numerous localities on the plateau, where, owing to the gradients, the difference of level between plateau and valley-bottom is much greater than at Currie Farm. Evidence derived from the character and conditions of preservation of these implements is adduced in favour of their great antiquity.

iii. *The Initial Stages of the Darent Valley.*—The author has previously shown that in early Pliocene times a plain of marine denudation extended over the present Vale of Holmesdale, and that in pre-glacial times the plain was scored by streams flowing from the high central Wealden ranges. These streams centred in the

Darent, and the excavation of the present valley then commenced. There is a gap in the sequence between the pre-glacial drifts and the earliest post-glacial drifts of the valley, which is probably covered by the extreme glacial epoch. It was a time of erosion, rather than of deposition in this area. Of the earliest drift of the Darent valley, little has escaped later denudation. The bank of coarse gravel on the hill on the west side of the valley between Eynsford and Farningham, certain flint-drifts in the upper part of the valley, and a breccia of chalk-fragments on the hill west of Shoreham, may be referred to this period.

iv. *The High-Level or Limpsfield Gravel Stage.*—The gravel at Limpsfield occurs on the watershed between the Darent valley and the Oxsted stream, but the author agrees with Mr. Topley that the gravel belongs to the Darent system, and Westheath Hill may be part of the original ridge separating the two valleys. This gravel is post-glacial, and the denudation of the area had made considerable progress at the time of its formation, for the Chalk escarpment rises 200–300 feet, and the Lower Greensand 100–200 feet above the gravel-bed. The author traces outliers of this gravel down the valley at lower and lower points to the Thames valley at Dartford, and correlates it, not with the high plateau-gravel, but with the High-level gravel of the Thames valley, and shows that its composition indicates that it is derived from the denudation of the Chalk and Tertiary beds. Mr. A. M. Bell has discovered numerous implements in it, mostly of the smaller St. Acheul type, and the author hopes that they will soon be described by their discoverer. These implements agree in general type with the "Hill group" of the Shode valley, and not with the older group of the Chalk plateau, or those of the lower levels of the Thames and Medway.

v. *Contemporaneous Drift of the Cray Valley.*—Implements of this age have been found by Mr. Crawshay, and by Mr. P. Norman, near Green Street Green, in gravel which is more than 100 feet below the Red Clay of the plateau.

vi. *Brick-earths of the Darent Valley.*—These are traced along the upper course of the valley from near Limpsfield. They seem to show glacial influence, and Mr. Bell has discovered a few implements in them. The Limpsfield deposit is from 10 to 30 feet below the adjacent gravel. Brick-earth, possibly of somewhat later date, also occurs near Dartford.

vii. *Other Gravels of the Darent Valley: The Chevening and Dunton Green Drifts.*—The relations of the gravels grouped under this head are more uncertain than those of the Limpsfield stage. Various features in the gravels point to the temporary return of glacial conditions during the period of formation of these and the brick-earths; and these are described in detail.

viii. *The Low-level Valley-Gravels.*—The correlation of these is also uncertain. West of Dartford is a bed corresponding with that at Erith in which Mr. Spurrell found a palæolithic floor. It contains land- and freshwater-shells. The surface of the Chalk is here festooned under a covering of the fluviatile drift. The author attributes this festooning to the effects of cold.

ix. *The Rubble on the Sides and in the Bed of the Valley.*—The author describes this rubble, and rejects the view that it is rain-wash or due to subaerial action, and discusses the possibility of its having been produced by ice-action.

x. *Alluvium and Neolithic Implements.*—These occur chiefly between Shoreham and Riverhead.

xi. *On the Chalk Escarpment within the Darent District.*—The author, after discussing and dismissing the view that the escarpment was formed by marine denudation, criticizes the theory that it was due to ordinary subaerial denudation, and lays stress on the irregular distribution and diversity of the drift-beds in the Darent area; these do not possess the characters which we should expect if they were formed by the material left during the recession of the Chalk escarpment owing to subaerial action; and he believes that glacial agency was the great motor in developing the valleys and, as a consequence, the escarpment, and that the denudation was afterwards further carried on in the same lines by strong river-action and weathering, though supplemented at times by renewed ice-action. By such agencies, aided by the influence of rainfall and the issue of powerful springs, he considers that the escarpment was gradually pared back and brought into its present prominent relief.

2. "On *Agrosaurus Macgillivrayi* (Seeley), a Saurischian Reptile from the N.E. coast of Australia." By Professor H. G. Seeley, F.R.S., F.G.S.

The complete left tibia, a less perfect proximal end of the corresponding right tibia. a fragment regarded by the author as a fibula attached to matrix which contains two laterally compressed claw-phalanges, are preserved in the British Museum, and are labelled "Fly," 1844, J. Macgillivray, from the N.E. coast of Australia. These remains are described, and the distinctive characters which determine the fossil (the distal end of the tibia) noted. It shows an ordinal resemblance with *Pœkilopleuron* and *Cetiosaurus*, but with *Dimodosaurus* from the top of the Keuper it is so close that the two must be regarded as nearly allied. The fossil is regarded as generically distinct from all known types. The remains indicate an animal about the size of a sheep, and it is considered as not improbable that the creature belongs to the Lower Oolites or Trias.

3. "On *Saurodesmus Robertsoni*, a Crocodilian Reptile from the Rhætic of Linksfield, in Elgin." By Professor H. G. Seeley, F.R.S., F.G.S.

The bone described in this paper was found in a mass which has been interpreted as a large boulder of Rhætic beds in Boulder-clay. The specimen has already been noticed by Sir Richard Owen and R. Lydekker, Esq. The author maintains that the bone is a right humerus. He discusses its asserted Chelonian affinities, and concludes that it is not Chelonian but Crocodilian, but that, if grouped with the Crocodilia, it belongs to a suborder hitherto unknown, and defined by a combination of Crocodilian and Lacertilian characters which is not Saurischian.

II.—February 4, 1891.—A. Geikie, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Geology of Barbados and the West Indies.—Part I. The Coral Rocks." By A. J. Jukes-Browne, Esq., F.G.S., and Professor J. B. Harrison, M.A., F.G.S.

The authors first discuss the reef growing round Barbados and describe a submarine reef, the origin of which is considered; and it is pointed out that there is no sign of any subsidence having taken place, but every sign of very recent elevation. They then describe the raised reefs of the island, extending to a height of nearly 1100 feet above sea-level in a series of terraces. The thickness of the coral-rock in these is seldom above 200 feet, and the rock does not always consist of coral-debris. At the base of the reefs there is generally a certain thickness of detrital rock in which perfect reef-corals never occur.

The collections of fossils made by the authors have been examined by Messrs. E. A. Smith and J. W. Gregory. Of the Corals, five out of ten species identified still live in the Caribbean Sea, and one is closely allied to a known species, whilst the other four are only known from Prof. Duncan's descriptions of fossil Antiguan Corals. The authors are of opinion that the whole of the terraces of Barbados, the so-called "marl" of Antigua, and the fossiliferous rocks of Barbuda are of Pleistocene age.

They proceed to notice the formations in other West Indian islands which appear to be raised reefs comparable with those of Barbados, and show that these reefs occur through the whole length of the Antillean Chain, and indicate a recent elevation of at least 1300 feet, and in all probability of nearly 2000 feet. It appears improbable that each island was a region of separate uplift, and as a plateau of recent marine limestone also occurs in Yucatan, this carries the region of elevation into Central America, and it is reported that there are raised reefs in Colombia. The authors conclude that there has been contemporaneous elevation of the whole Andean Chain from Cape Horn to Tehuantepec and of the Antillean Chain from Cuba to Barbados. Before this there must have been free communication between the Atlantic and Pacific Oceans, which is confirmed by the large number of Pacific forms in the Caribbean Sea. Under such geographical conditions the great equatorial current would pass into the Pacific, and there would be no Gulf Stream in the North Atlantic.

2. "The Shap Granite, and the Associated Igneous and Metamorphic Rocks." By Alfred Harker, Esq., M.A., F.G.S., and J. E. Marr, Esq., M.A., Sec. G.S.

The authors describe the normal granite of the intrusion, and discuss the characters of certain variations from the usual type.

The dykes and sills of the neighbourhood are also considered; the similarity of some of these to certain inclusions in the granite is noticed; and reasons are given for supposing that many of the felsites and mica-traps of this region are connected with a magma which was intruded amongst the Lower Palæozoic rocks in pre-

Carboniferous times, and with which the Shap granite is itself connected.

The metamorphic effects of the granite upon the surrounding rocks are then described. A remarkable set of changes produced in a series of andesites and another of rhyolites, with their respective pyroclastic rocks, is considered in detail, and the results of the metamorphism of the Coniston Limestone series and the Coniston Flags and Grits are given and compared with those obtained by other workers in Norway, the Harz Mountains, and elsewhere.

CORRESPONDENCE.

MR. OLDHAM ON THE HIMALAYAS.

Sir,—It is needless to say how much it has pleased me that Mr. Oldham's knowledge of the structure of the Himalayas confirms in his opinion my theory, published in the "Physics of the Earth's Crust," concerning the formation of a mountain range, and of the effects of its subsequent denudation. I wish, however, to point out that the latter are in my work discussed on the hypothesis that the chief streams are formed, and deposit their sediment, on the less steep side of the range. I had rather the instance of the Andes in my mind as a typical range of mountains. With the Himalayas the case is different. The great rivers, Indus and Ganges, after collecting their burden of detritus during long courses between the parallel ridges, finally break through the steep face of the range, and form their deposits on that side. Hence arises the modification of my theory, which Mr. Oldham has found it necessary to make in applying it to the denudation of the Himalayas. O. Fisher.

Harlton, Cambridge, 5 *Feb.* 1891.

MR. MELLARD READE AND THE HERSCHEL-BABBAGE THEORY OF MOUNTAIN BUILDING.

Sir,—The theory of the formation of mountains set forth by me in "The Origin of Mountain Ranges" has been so frequently of late alluded to as a modification of the "Herschel-Babbage" theory, that I shall feel much obliged if one of those who think it so will kindly set forth what the "Herschel-Babbage" theory is. I fear that my friend Mr. O. Fisher is largely responsible for this description of my theory.[1] I have examined his references to the works of Herschel and Babbage, and must certainly repudiate the labelling as a misdescription. There is no analogy between Herschel's view of the elevation of mountains and mine, and indeed by a sort of dramatic justice I find that Mr. R. D. Oldham[2] commends Mr. Fisher's work as containing the "most recent and complete adaptation of this (the Herschel-Babbage) doctrine to the theory of mountain formation."

As a matter of fact, the only element in my theory taken from either of these distinguished men is the law discovered by them that the lines of equal internal temperature in the Earth's crust (isogeotherms) must move upwards into new deposits as they are laid down. This is duly acknowledged in chap. vii. and credited to Babbage, who, I believe, has priority; but should the use of a natural law in building up a theory disentitle the theoriser to the full right of property in his own theory?

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[1] Physics of the Earth's Crust, second edition, p. 132.

[2] Geol. Mag. Feb. 1891, p. 73.

It is said, "What's in a name?" To which I answer, A great deal that is bad when it is vague and misleading and perpetuates errors and misconceptions. T. Mellard Reade.

Park Corner, Blundellsands, *Feb. 9th*, 1891.

CRINOIDAL STEMS IN ORDOVICIAN OF SWEDEN.

Sir,—I am glad to have elicited from Dr. Holm such interesting information about the crinoid stems that he has found in the Leptænakalk of the Lissberg. But I am sorry that my remark has given rise, perhaps not unnaturally, to some misunderstanding. Dr. Holm in his original notice says two things:—First, that the rock is "chiefly composed of corals, cystids, and crinoid stems;" secondly, that he himself has found there "crinoid stems belonging to at least two species." Now I never doubted that so experienced a palæontologist as Dr. Holm had very good reasons for this latter statement; his letter shows how sufficient those reasons were. Nor did I "without having seen a single one of them," venture to assert that all the stem-fragments belonged to Cystidea. I was indeed well aware of the sessile nature of the majority of the Cystidea from this locality. But, remembering as I did how often stems undoubtedly cystidean had been referred to Crinoids, and knowing that not a single Crinoid had been recorded from the Ordovician of Sweden, though 23 species of Cystidea showed the possibility of their preservation, I merely wished, as indeed I still wish, to suggest that some of these ossicles might have pertained to the long and exceedingly crinoid-like stem of *Caryocrinus*. So inevitable did this seem that, though I did not so far forget either myself or Dr. Holm's very valuable works as to call him a mere collector, still I did express myself in a manner which now seems to me to need an apology, and this I trust, Sir, you will here permit me to offer. F. A. Bather.

5 *Feb.* 1891.

MOTION OF LAND-ICE.

Sir,—As I have paid some attention to Glaciers,[1] I should like to make a few remarks on the paper by Mr. Goodchild on "The Motion of Land-ice" in the Geol. Mag. for January last, pp. 19–22.

1. The expansion and contraction of ice for changes of temperature below 0° C. and under a pressure of one atmosphere is but an example of the general law for solids, which has been recognized for many years in physical science; and the power of ice to resist tensile strain is (as Helmholtz has pointed out) so small as to furnish an explanation of the formation of crevasses, though these are not by any means always produced by contraction due to lowering of temperature. But this very property of ice shows that contraction

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[1] Q.J.G.S. vol. xxxix. pp. 62–71, "On the Mechanics of Glaciers"; also 'Nature,' vol. xxvii. pp. 553, 554, "On Solar Radiation and Glacier-motion."

of the upper layers can neither help (*per se*) the downward flow when the temperature rises again, because the expansion being equal to the previous contraction (*cet. par.*), it must result merely in the closing-up of the shrinkage-cracks; nor can it tend to produce a curvature of the lower layers (after the fashion of the balance-wheel of a chronometer) as seems to be suggested later on in Mr. Goodchild's paper. In the former case water, produced by the melting either of the surface of the glacier or of the snow-mantle overlying it, during hours of sunshine, and flowing into the cracks, would certainly by its expansion in freezing do some work; but what becomes of its *latent heat?* The distribution of this in the neighbouring ice needs to be considered.

2. If by 'cold-waves' Mr. Goodchild means (as I take it) 'flows' of heat by conduction from the warmer interior to the surface whose temperature is below 0° C., it is a pity he did not speak of it as such. Cold, like darkness, is a negation; and we can only speak of a wave of either metaphorically.

3. We had no need to go back nearly half a century to Brunner's investigations to convince us that the 'sole' of a glacier moves down a slope; the observations and measurements by Tyndall, Helmholtz, Forbes, Agassiz, and others have made that pretty certain.

4. As to the "uphill movements" postulated by Mr. Goodchild and many writers who have preceded him, I have for a long time been very sceptical, as may be seen from my papers referred to above; and the researches of Penck[1] on the glaciation of the Northern Alps have converted that scepticism into positive disbelief, since all that I have read or heard alleged, as evidence of such movements, is more rationally explained by the *overflow* of the glaciers beyond their valley-sides during periods of maximum glaciation, and by the phenomena of stranded lateral moraines during the recession of a glacier, with which every Alpine observer is familiar (*e.g.* the Morteratsch).

5. The theory of "isogeotherms" continued through the lower parts of a glacier will not work, except for a hypothetical case where the adjacent rocks and the ice were all considerably below 0° C., because no heat at any higher temperature could be conducted through or into the ice, as seems to be imagined: it would become latent in the melting of the ice at the contact. This is probably the reason why previous writers have "overlooked" the fiction which Mr. Goodchild has now gravely put forward as a "fact."

6. Mr. Goodchild has overlooked three factors essential to the construction of any sound physical theory of glacier-motion; (i.) liquefaction under pressure and regelation; (ii.) the "greenhouse-principle," the application of which to glacier-motion was demonstrated by myself in the paper in *Nature* already referred to; (iii.) the latent heat of water, the 80 gramme-units of heat given up by every gramme of water at 0° C. in the act of solidifying under ordinary pressure. A. Irving.

Wellington College, Berks, *Jan.* 8.

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[1] See "Die Vergletscherung der Deutschen Alpen," reviewed in the Geol. Mag. Dec. II. Vol. X. p. 174, *et seq.*

ELEVATION AND SUBSIDENCE IN CENTRAL AMERICA.

SIR,—Allow me to point out that Mr. W. Upham's letter in the February Number of this MAGAZINE is not an answer to my article in that for December, 1890; because he completely ignores the point of my communication and re-asserts views which I did not question.

In his original article of November, 1890, Mr. Upham cited the Gulf of Mexico as having partaken in the high continental elevation and in the subsequent subsidence to an extent of 3000 feet. In December I quoted facts to prove that on the south side of the Gulf of Mexico there has been a recent upward movement of probably 2000 ft. Hence if the Mississippi subsidence was contemporaneous with the Cuban elevation, there must have been a differential movement of 5000 feet within a comparatively small area.

I do not say the difficulty is unsurmountable; the axis of the one oscillation may not have been located along the same parallel as the axis of the other oscillation, or if Mr. Upham likes he can postulate a great east and west fault through the Gulf of Mexico, with a downthrow on the north of about 5000 feet. The point, however, does require notice, and it is not noticed at all in the letter which purports to be a reply. I will therefore put the difficulty more fully. During Pliocene and Pleistocene time there was in North America a great elevation followed by a great subsidence; and in Central America a subsidence followed by great elevation. If these movements were correlative, should we not expect to find a zone where there was no movement at all? Would not the greatest vertical displacement be found in Canada or the Northern States, and the least in the Southern States, and would not the evidences of subsidence die away southward, and then be replaced by evidences of upheaval? Instead of this, we find the movements almost at a maximum in those parts of the two areas which are nearest to one another. Can Mr. Upham refer to any evidence about alteration of levels along the west coast of the Gulf of Mexico?

In a paper just read before the Geological Society, I have adduced evidence of the recent uprise of the Caribbean and Panamic region, and have advocated the view that the Gulf Stream passed into the Pacific while the Glacial Period prevailed in the North Atlantic. I am therefore strongly disposed to agree with the general views put forward by Mr. Upham as to the geographical conditions that prevailed during that period; but in generalizing about the movements which have affected such vast areas, we cannot be too careful about the accuracy of the data on which the inferences are based, and nothing is gained by ignoring difficulties.

It was because I thought that this difficulty might not have occurred to Mr. Upham that I put it before him; but I shall be very pleased to see it answered in a manner that will strengthen Mr. Upham's theory of correlative movements, and I hope Dr. Spencer, who wrote much more cautiously than Mr. Upham, may shortly have something to say about the date of the great depression.

TEIGNMOUTH, *February 7th.* A. J. JUKES-BROWNE.

OBITUARY.

GEORGE WAREING ORMEROD, M.A., F.G.S.

Among the losses recently sustained by geological science, we have to record that of Mr. G. W. Ormerod, who died at Teignmouth on January 6th, aged 82. He was a son of the late George Ormerod of Tyldersley House, Lancaster, and Sedbury Park, Gloucester, well known as the author of "The History of Cheshire." The Ormerods were a family which had been connected with Ormerod Hall, near Burnley, in Lancashire, since the time of Edward III.

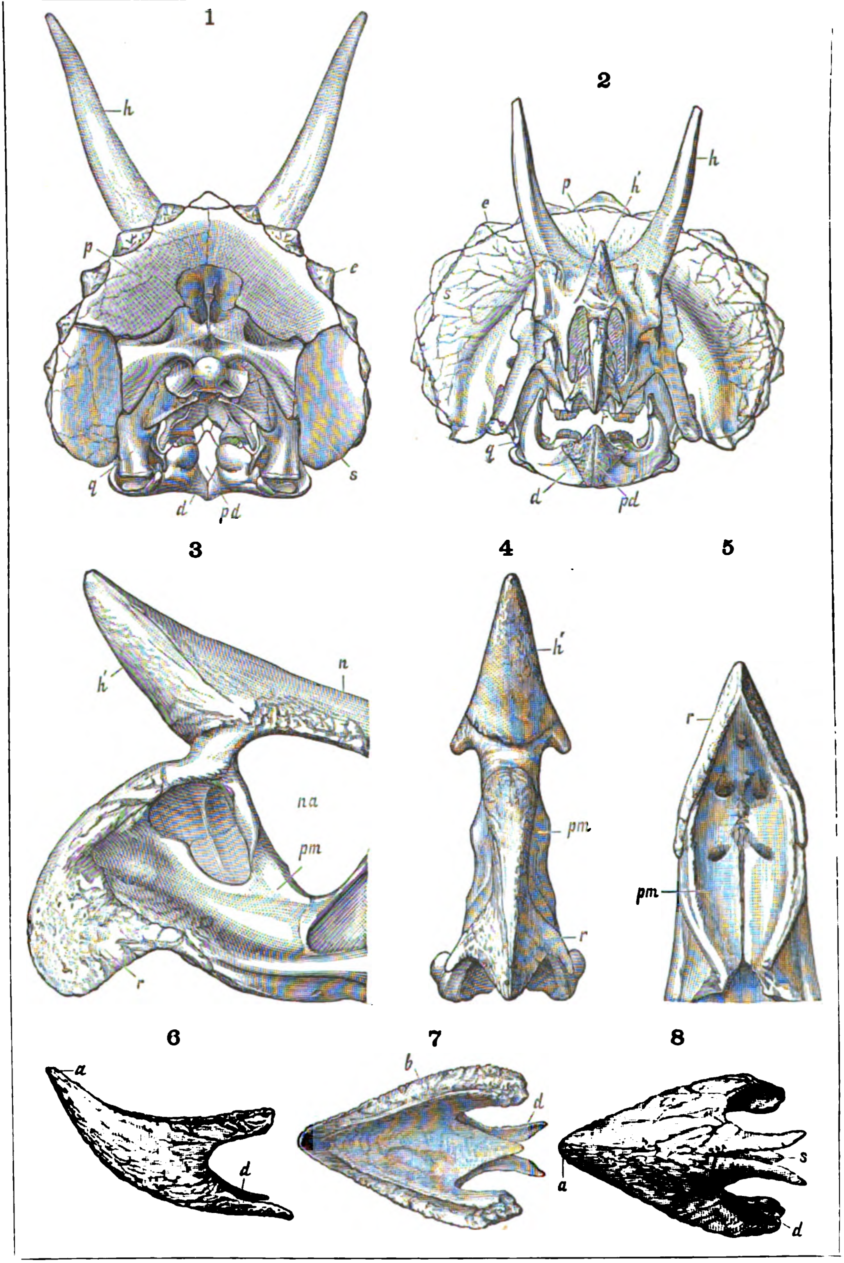
G. W. Ormerod, after taking his degree at Oxford, practised for some years in the law at Manchester; he subsequently resided at Chagford on the borders of Dartmoor, and for the last twenty years at Teignmouth. To the country in which he resided he devoted most of his attention as a geologist. His papers included the following: an Outline of the principal Geological Features of the Salt-field of Cheshire and the adjoining districts; on the "Waterstone Beds" of the Keuper; on some Veins of Granite in the Carbonaceous Rocks on the North and East of Devon and East of Dartmoor; Geology of the upper part of the valley of the Teign; on the Structure of the Granite of Dartmoor; and papers on the New Red rocks of the neighbourhood of Teignmouth. To geologists he was perhaps best known as the compiler of the Classified Index to the Transactions, Proceedings, and Quarterly Journal of the Geological Society, of which the third supplement (up to 1889) was published last year. He was one of the original members of the Devonshire Association, and one of the founders of the Teign Naturalists' Field Club, of which for many years he was Secretary.

WILLIAM DAVIES, F.G.S.

We regret to record the death of Mr. William Davies, F.G.S., for forty-four years connected with the Geological Department of the British Museum. Mr. Davies was born at Holywell, Flintshire, in 1814, and entered the Museum on 19th Dec. 1843. He had already studied Botany, and had made a good *Hortus siccus* of British plants. Under Mr. Charles König, he devoted himself to Mineralogy, and soon became an excellent eye-mineralogist. He also worked at the fossil fishes in the Museum, many of which he afterwards described in this Magazine. He devoted many years of patient study to the fossil Vertebrates, but his knowledge was generously given to others as soon as solicited. With Sir Antonio Brady he formed a fine collection of the Mammalian-remains from the Thames-Valley Brick-earth, which he described and catalogued. The Geological Society of London, in 1873, awarded Mr. Davies the first Murchison Medal; and in 1877 elected him a Fellow of the Society, the Council presenting him with the Life Fellowship.

In 1875 Mr. Davies was made an Assistant, and in 1880 promoted to the First Class, in recognition of his valuable services. He took a very active part in the removal and re-arrangement of the Geological Collections at Cromwell Road, from 1880 to 1887, when he retired on a pension. He died on the 13th February last, warmly esteemed and deeply regretted by all who knew him.

A list of his papers will appear in next month's issue.—H. W.



THE GIGANTIC CERATOPSIDÆ.

To illustrate Prof. O. C. MARSH's second paper on *Triceratops*, from the Upper Cretaceous of North America (May, 1891); see also *previous paper* in GEOL. MAG. Decade III. Vol. VII. Pl. I. pp. 1—5, 1890.

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No. IV.—APRIL, 1891.

ORIGINAL ARTICLES.

I.—On New Specimens of *Dendrerpeton Acadianum*, with Remarks on other Carboniferous Amphibians.

By Sir J. William Dawson, LL.D., F.R.S., etc.

THE genus *Dendrerpeton* was established by Owen on the evidence of remains found by Sir C. Lyell and the writer in an erect tree at the South Joggins in Nova Scotia in 1852.[1] Other specimens were afterwards obtained, and the most complete, presented by me to the Cabinet of the Geological Society, was found in 1861, and described in my "Airbreathers of the Coal Period."[2] These remains rendered it certain that the animal belongs to the order Labyrinthodontia,[3] and it is regarded by Lydekker as the type of a family in that group.[4]

As the characters of the type-species ascertained by Owen and by the writer have not as yet been stated in connected form, and the genus may in consequence be said to be still imperfectly known, it may be useful to sum them up before proceeding to notice some specimens recently obtained, and which have added somewhat to our knowledge of the type-species.

Dendrerpeton Acadianum, Owen, Journ. Geol. Soc. Lond. vol. ix. 1853.

Skull of moderate size and rounded broadly in front. Nostrils small and near the muzzle. Orbits nearly in the middle of the length. Occipital condyle double. Parietal foramen small. Surface of cranial bones sculptured with relatively deep pits. Teeth conical, smooth above, grooved at base, especially on the inner side; enamel simply plicated at base. Outer series of teeth somewhat unequal and larger anteriorly in the intermaxillary bones. A few large teeth within on the inner surface of the maxillaries. A group of small simple teeth on the vomerine bones. Mandibles sculptured like the skull, but much more feebly. Teeth similar to those in the upper jaw, but not larger in front. For the arrangement of the central cranial bones see diagram in Memoirs on Animal Remains in Erect Trees, Phil. Trans. Royal Society, 1882, pl. 44.

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[1] Journ. Geol. Soc. of London, vol. ix. p. 66. A preliminary examination of the specimens had been made by the late Prof. J. Wyman, of Cambridge, U.S., and was quoted by Prof. Owen.

[2] Montreal, 1863. See also Journ. Geol. Soc. vol. xvi. p. 273; vol. xviii. p. 5; and vol. xix. p. 470.

[3] Journ. Geol. Soc. vol. xv. p. 274; also "Airbreathers of the Coal Period."

[4] Brit. Museum Catalogue, Reptiles and Amphibia, vol. iv. p. 170; also Nicholson and Lydekker, Manual of Palæontology, vol. ii. p. 1032.

Vertebræ imperfectly ossified, very slightly biconcave, with large and broad neural processes in dorsal region. Those of the tail have spines above and below. Ribs of moderate length, with expanded head and slight shoulder; solid towards the head, but hollow and thin-walled at distal end, the longest barely equal to the breadth of the skull, curved, the anterior ones very much so, scapular and pelvic bones large and well ossified. Ilium? broad.

Limbs well developed, especially the anterior pair. Limb-bones ossified and cancellated at the extremities, and with bony walls of considerable thickness. Humerus equal to more than half of the length of the mandible. Femur smaller than humerus, the tibia flattened at the extremity. Toes five in each foot, somewhat broad and short.

Chest covered with bony scales, which are thin, unequally ovate and about half as wide as long, and marked with obscure concentric lines. They have a thickened edge or margin interiorly. They are arranged in chevron and close together, forming a compact armour. There appears to have been a rhombic breast-plate in front, with obscure radiating lines, but this has only been found detached.

Skin of upper surface of body minutely granular or scaly, with a semicircular patch of horny tubercles in front, which I have referred to the snout, but it may have belonged to the back of the head. On the throat or sides were flat, pointed, and apparently flexible lappets marked with elongated areoles and pores. Nearly the whole skin of some specimens has been preserved in the erect trees apparently by a sort of tanning process, but it is so flattened and crumpled that its form is scarcely discernible.

The following are the dimensions of two specimens, one of them (No. 2), that of 1890, and the largest yet obtained:—

	No. 1.	No. 2.
Length of Skull*	7 centimetres.	9 centimetres.
Breadth of Skull*	5 ,,	6 ,,
Length of Mandible	6·6 ,,	8·6 ,,
,, Humerus	3·5 ,,	4·3 ,,
,, Ulna	2·5 ,,	— ,,
,, Femur	2·6 ,,	— ,,
,, Rib	2· ,,	2·8 ,,
,, Eleven vertebræ	5·6 ,,	— ,,

* The skulls being flattened and crushed, these measurements are not certain.

In form, *Dendrerpeton Acadianum* was probably elongated and lizard-like; with a broad flat head, short stout limbs, and an elongated tail; and having the skin of the belly protected by small bony plates closely overlapping one another, while the upper part of the body was covered with a tough skin more or less scaly and ornamented in parts with lappets or pendants. As in the case of other small Reptilians of the Coal, its enemies were found rather below than above. Its armour therefore was beneath.

The bone-cells are broad and with much-branched canaliculi, those of the bony scales being similar to those of the other bones. The hollow bones are occupied with calcite stained brown and probably representing cartilage.

Not having visited the Joggins for some years, and the gentleman on whom I had relied to give me intimation of new exposures of reptiliferous trees having left the locality, I made a short excursion to the place last summer, and found two trees partially exposed in the reef. These were extracted with the kindly aid of Mr. McNaughton, Superintendent of the Joggins Mine, but unfortunately proved unproductive. A large tree had fallen from the cliff in the previous winter and had possessed a layer of very productive material in its lower part, much of which had however been removed by the waves. I succeeded in obtaining a portion of this material, which on examination proved to contain parts of the skeletons of two specimens of *Dendrerpeton Acadianum* and one of *D. Oweni*. No other reptilian bones nor remains of millipedes or of land shells were observed.

The specimens of *D. Acadianum* were the largest yet found, and some of the bones were in a more perfect state. As examples of these I figure (Fig. 1) the two mandibles of the largest specimen. These seem to have separated on the decay of the body and to have fallen across one another, so that they lie side by side and reversed. They are 8·6 centimetres in length, and one of them shows very well the corrugated sculpture of the bone and a number of the teeth. On the same slab, represented in Fig. 1, is a well-preserved humerus. It has been exposed by cleaning away some of the stone, which probably contains other bones of the fore-leg; but they cannot be worked out without destroying those in sight.

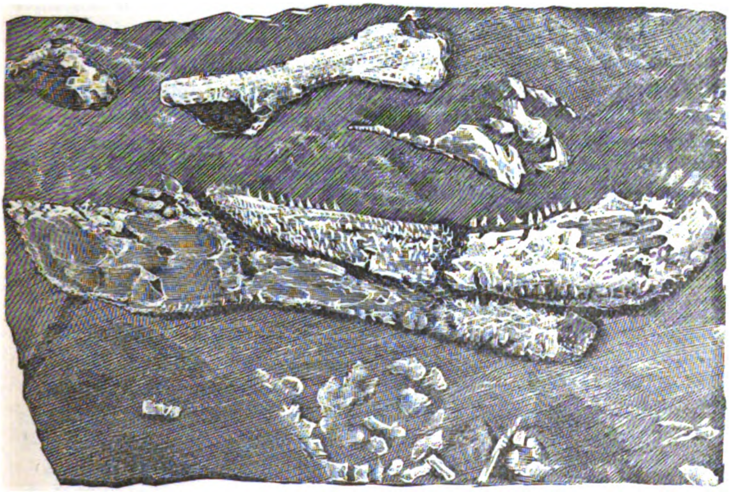

Fig. 1.—Humerus and Mandibles of *Dendrerpeton Acadianum*. Natural size.

I would call attention to the humerus as indicating the development of the fore-limb in this species. The bone in this probably mature specimen is better ossified than in smaller and probably younger specimens. In length it is 4·3 centimetres, or half that of the mandible, thus exceeding in relative size the humerus of the American Alligator, while its form indicates a limb of much muscular power. Other specimens show that the hind-limb was not larger than the fore-limb; on the whole it was perhaps feebler, so that in this animal there was no approach to that exaggerated size of the hind-limb seen in some of the larger Labyrinthodonts.

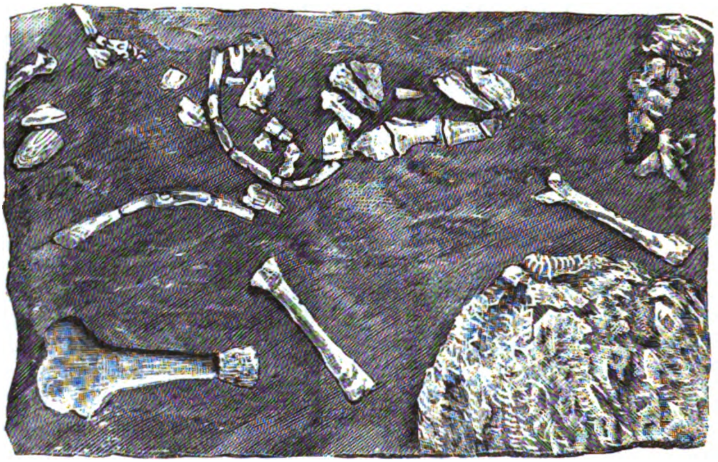

Fig. 2.—Ribs, Phalanx, Scales, Scapular bones, and part of Skull of *Dendrerpeton Acadianum.* Natural size.

The slab represented in Fig. 2 shows the anterior part of the crushed skull, giving its broadly rounded form in front, and the sculpturing of the bone. After the photograph from which the cut is copied was taken, a portion of the matrix was removed, so as to expose the outer teeth on one side and one of the large inner teeth. One of the former with the sculpturing of the edge of the maxillary bone is represented enlarged in Fig. 3.

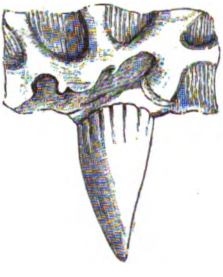

Fig. 3.—Outer tooth and portion of Maxillary bone of *Dendrerpeton Acadianum.*—Enlarged.

On the slab Fig. 2 are two slender bones and a larger bone which I suppose to be parts of the shoulder-girdle. There are also two of the anterior ribs and some bones of the foot (among them a phalanx) showing portions of four of the bones in position, and giving for one of the toes of the fore-foot a length of about 2·3 centimetres; also a few of the anterior abdominal scutes. All the bones represented belong to the anterior parts of the animal; the portion of the tree containing its posterior parts had unfortunately been destroyed or removed by the sea.

I have remarked in previous memoirs that possibly the animals found in the erect trees, while they must all have been of terrestrial rather than aquatic habits, may in some cases have been young individuals of the species to which they belonged. This supposition is to a certain extent borne out by the present specimens, which are considerably larger than the corresponding parts of individuals previously found, and have the bones more ossified and more strongly sculptured. Possibly, however, we may not yet know the species in its full magnitude.

This suggests the question whether *D. Oweni* may be founded on still younger individuals of the same species. The likelihood of this is not, however, increased by the new discoveries. The specimen of *D. Oweni* found in the tree of 1890 is quite as distinct as those previously found. It has longer, more curved and pointed teeth, thinner and less sculptured cranial bones. The mandibles are only very feebly sculptured. The limbs and feet seem to have been similar to those of *D. Acadianum*, but the abdominal bony scales were narrower and more pointed or "oat-shaped," and the skin of the upper surface more distinctly scaly. On the whole, therefore, the evidence is in favour of *D. Oweni* having been a smaller species allied to, but presenting so far as known no connecting links with, its larger congener.

Hylonomus Lyelli, Dawson, Journ. Geol. Soc. Lond. vol. xv. 1859, p. 274.

Though the newly-found specimens throw no farther light on the amphibians of the group *Microsauria* found in the same repositories with *Dendrerpeton*, they have invited comparison and fresh study of the material previously obtained, and I desire in this connexion to state the reasons which have induced me from the first to maintain that *Hylonomus*, *Hylerpeton*,[1] *Smilerpeton*, and *Fritschia*[2] are not Labyrinthodonts properly so called, and belong to a quite distinct group, making in some respects nearer approach to the reptilian order to which the *Proterosaurus* of the Permian belongs.

We may take *Hylonomus Lyelli*, the best known of these animals, as a type, and I would state the following points of comparison with *Dendrerpeton*, and most if not all other typical Labyrinthodonts.

1. As to the skull, this is large behind and pointed in front, and its bones are smooth, while the teeth are perfectly simple, without any trace of fluting or plication of the enamel, and there are no interior large teeth. The nasal and maxillary bones are smooth, thin, and elongated. The parietal bones larger and more convex

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[1] Owen, J.G.S. vol. xviii. 1862, p. 241.

[2] Dawson, Phil. Trans. Royal Society, 1882, pt. ii. pp. 638, 641.

than in most other amphibians. The bone which I suppose to be the parasphenoid has a long axial process, and the posterior end moderately broad. On the other hand, it is certain that the skull has an open parietal foramen, has a group of small palatal teeth, and has two occipital condyles.

2. As to the trunk. The vertebræ are long, hour-glass-shaped, biconcave, and ossified exteriorly, with large and broad neural and lateral processes. The ribs are well developed, curved, and with a double head. The scapular and pelvic bones are large, especially the latter, which has a very broad well-ossified principal bone, perhaps the ilium. The pelvic bones thus resemble those of *Diplovertebron*[1] of Fritsch, which is, however, an animal very different in other respects. I regret that I have had no means of ascertaining whether the pelvis of *H. Lyelli* was attached to one sacral vertebra or more. The large size of the pelvis would, however, render its attachment to a single vertebra improbable, and in the skeletons on the slabs (*a*) and (*b*), Fig. 4, there are in the vicinity of the pelvis pairs of vertebræ attached to each other in such a manner as to suggest that they were permanently united.

3. The limb-bones and ribs have a thin and hard outer bony coat, the interior being usually filled with calcite darkened by organic matter, probably remains of cartilage. The bones of the limbs and feet are long and slender, with well-ossified extremities, and their forms indicate slender limbs and active habits. The hind-limb in particular is somewhat larger than the anterior; and this with the size of the pelvis indicates a form of body broader behind, narrower in front. In farther connexion with this I have remarked in former papers that the skeletons of this animal always lie *on the side*, indicating that the body was flattened, not vertically, but laterally, as in some Lizards. This I regard as an important diagnostic character for *Hylonomus*, and it does not seem to apply to the genus *Hyloplesion* of Fritsch, which is flattened vertically, as well as much inferior in development of pelvis and limbs.

4. As to dermal covering, *Hylonomus* has the abdomen protected by bony scales, but differing in form and probably in arrangement from those of *Dendrerpeton*. The covering of its upper part was however peculiar to itself, presenting a perfectly scaly surface of true corneous scales and with ornamental tubercles and spiny epaulettes on the shoulders, of which there is no trace in any other known amphibian, recent or fossil. It also possessed pendant fringes of cuticle like those of *Dendrerpeton*.

In connexion with this statement, I copy here (Fig. 4) from my "Airbreathers of the Coal Period" an illustration of the scattered bones of a skeleton of *Hylonomus Lyelli*, and some of the parts enlarged, which will serve with the accompanying description to illustrate some of the structures. I have given in the paper above referred to, in the "Transactions of the Royal Society," a copy of a portion of the scaly armour from a micro-photograph.

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[1] Plate 52, Fauna der Gaskohle. As interpreted by Fritsch, the flat bone is called the pubis.

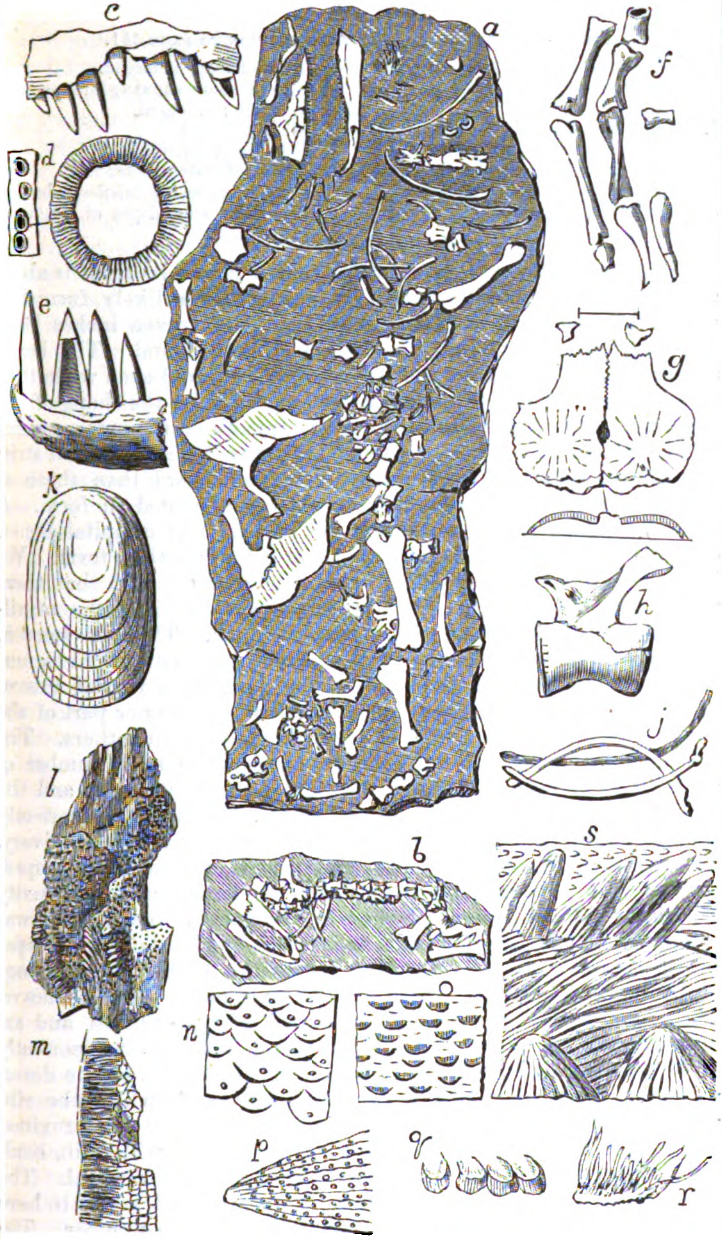

FIG. 4.—*Hylonomus Lyelli.*[1]

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[1] **Reprinted from "Airbreathers of the Coal Period," 1868.**

FIG. 4.—*Hylonomus Lyelli.* EXPLANATION TO PAGE 151.

a. Skeleton in matrix, showing jaws, ribs, vertebræ, pelvis, and bones of limbs.
b. Portion of skeleton in matrix, showing vertebræ and limb-bones.
c. Portion of maxilla with teeth; enl.
d. Cross-sections of teeth; enlarged.
e. Anterior end of mandible with teeth; enlarged.
f. Bones of foot; enlarged.
g. Parietal bones, showing foramen; enl.
h. Vertebra; enlarged.
j. Ribs; enlarged.
k. Bony scale; enlarged.
l. Portion of scaly cuticle.
m. to *s.* Horny scales, bristles, tubercles, and other appendages of the same; magnified.

Hylonomus Lyelli was an animal of small size. Its skull is about an inch in length, and its whole body, even if, as was likely, furnished with a tail, could not have been more than six or seven inches long. No complete example of its skull has been found. The bones appear to have been thin and easily separable; and even when they remain together, are so much crushed as to render the shape of the skull not easily discernible. They are smooth on the outer surface to the naked eye, and under a lens show only delicate uneven striæ and minute dots. They are more dense and hard than those of *Dendrerpeton*, and the bone-cells are more elongated in form. A specimen in my possession shows the parietal and occipital bones, or the greater part of them, united and retaining their form. We learn from them that the brain-case was rounded, and that there was a parietal foramen. Well-preserved specimens of the maxillary and mandibular bones have been obtained. They are smooth, or nearly so, like those of the skull, and are furnished with numerous sharp, conical teeth, anchylosed to the jaw, in a partial groove formed by the outer ridge of the bone. In the anterior part of the lower jaw there is a group of teeth larger than the others. The intermaxillary bone has not been observed. The total number of teeth in each ramus of the lower jaw was about forty, and the number in each maxillary bone about thirty. The teeth are perfectly simple, hollow within, and with very fine radiating tubes of ivory. The vertebræ have the bodies cylindrical or hour-glass-shaped, covered with a thin, hard, bony plate, and having within a cavity of the form of two cones attached by the apices. This cavity was completely surrounded by bone, as it is filled with stained calc-spar in the same manner as the cavities of the limb-bones. It was probably occupied with cartilage. The vertebræ were biconcave. The neural spines are short and broad, with zygapophyses, and are not separable from the bodies, the neural arches being perfectly anchylosed to the bodies of the vertebræ. There are, on the dorsal vertebræ, strong diapophyses or lateral spines, to which the ribs were articulated. The ribs are long, curved, and at the proximal end have a shoulder and neck. They are hollow, with thin, hard, bony walls. There are short ribs which may be cervical. The anterior limb, judging from the fragments procured, seems to have been slender, with long toes, four or possibly five in number. The posterior limb was longer and stronger, and attached to a pelvis so large and broad as to give the impression that the creature enlarged considerably in size towards the posterior extremity of the body, and that it may have been in the habit of sitting erect. The thigh-bone is well formed, with a distinct head, and the lower extremity flattened and moulded into two articulating surfaces for the tibia and fibula, the fragments of which show that they were much shorter. The toes of the hind-feet have been seen only in detached joints. They seem to have been thicker than those of the fore-foot. Detached vertebræ, apparently caudal, have been found, but the length of the tail is unknown. The limb-bones are usually somewhat crushed and flattened, especially at their articular extremities, and this seems to have led to the error of supposing that this flattened form was their normal condition; there can be no doubt, however, that it is merely an effect of pressure. The limb-bones present in cross-section a wall of dense bone with elongated bone-cells, surrounding a cavity now filled with brown calc-spar, representing cartilage. Nothing is more remarkable in the skeleton of this creature than the contrast between the perfect and beautiful forms of its bones, and their imperfectly ossified condition, a circumstance which raises the question whether these specimens may not represent the young of some reptile of larger size.

The dermal covering of this animal is represented in part by oval bony scales, which are so constantly associated with its bones that I can have no doubt that they belonged to it, being the clothing of its lower or abdominal parts; while above it was clad in the beautiful scaly covering above described. The scales are thicker than those of *Dendrerpeton.* On the inner side they are concave, with a curved ledge or thickened border at one edge. On the outer side they present concentric lines of growth. The companion genera above named are not known so completely as *Hylonomus*, but all their characters so far as known would place them with it as members of the same group rather than with *Dendrerpeton* and its allies. Of other American forms it appears to me probable that *Sauropleura digitata* of Cope[1] may be very near to my genus *Fritschia,* and agrees with it in having rod-like abdominal scales, but its head is not yet known. *Brachydectes* of the same author is very near to *Hylerpeton,* especially as specimens of the latter recently obtained show some characters, as the ascending ramus of the lower jaw, on which Cope distinguishes this genus.

Of Fritsch's species several may come within the group of Microsauria. The genus *Hyloplesion* of this author has indeed been united by Credner with *Hylonomus,* a position to which it scarcely seems entitled, and *Petrobates* of Credner is nearly allied, while *Seelya* and *Dawsonia* of Fritsch also approach to the characters of this order. Still the whole of these animals seem very inferior in development of limb and form of body to *Hylonomus.*

I regret very much that, owing, as I believe, to imperfection of material, so many palæontologists have failed to appreciate fully the characters of *Hylonomus* as a type of the higher Carboniferous Amphibia approaching to Reptilia.

Fritsch, in the conclusion of his important work on the Stegocephala of the Gas-coal of Bohemia, has some valuable remarks on the affinities of these animals; and, though I can by no means agree with the manner in which he arranges them in families, or with the way in which he mixes up Labyrinthodontia and Microsauria with other creatures so different as the Branchiosauridæ and the Ophiderpeton group, I think his conclusions deserve mention, and may state them nearly in his own words as follows:—

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[1] Ohio Reports, vol. ii. p. 388.

After remarking on the fact that we know no clear links of derivation from any previous animals, he states that on any theory of derivation different origins must be supposed. He illustrates this by the characters of the vertebræ in different genera, as, for instance, the biconcave, the partly cartilaginous, and the diplovertebrate types.

Whatever view may be taken of their origin, the increased knowledge of their structures has not made clear as yet their precise relation to modern Amphibia and Reptilia; and only serves to make us doubt whether the distinctions recognized in the modern forms apply to these ancient creatures in the same degree. We seem indeed to have, both in the Labyrinthodonts and the Microsaurians, composite or generalized types having properties akin to those of both classes, and these in very different degrees. If we regard them all as agreeing in the general structure of the skull, with its free parasphenoid, and a similar set of bones in the shoulder-girdle, then we shall find that in other respects we have a heterogeneous assemblage, some agreeing in the formation of the vertebræ, ribs, and pelvis, with Amphibians, others with Reptiles; and there are corresponding differences in the dermal covering. If we attempt to group these creatures in orders and families, we are met with very great difficulties, owing to the variety and kinds of their differences, which, in connection with the imperfection of the material, almost defy the classifier.

So far Fritsch, and I may add that I consider that little is gained by grouping animals so diverse in organization under one head of Stegocephala in consequence of resemblances in certain cranial bones, and that a more general and large view should be taken of the *tout ensemble* of their structures.

With reference to that selection of these animals which has been preserved in the erect trees of Nova Scotia, the only ones which it has been necessary for me to study, I have no hesitation in placing in two orders or families, that of the Labyrinthodontia, to which *Dendrerpeton* belongs, and that of the Microsauria, including *Hylonomus*, *Hylerpeton*, *Fritschia*, and *Smilerpeton*, all of which have many important points in common. The other forms I leave to those who have to deal with them, but I feel convinced that some of them should be separated, probably ordinally, from the above.

The following extract from Credner on the systematic position of *Hylonomus* and *Petrobates*, shows that he to some extent shares in these views.[1] It should be understood, however, that his *Hylonomus* is *Hyloplesion* of Fritsch, and possibly not congeneric with *Hylonomus* proper, and certainly less reptilian in its characters.

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[1] Zeitsch. Deutsch. geol. Gesellsch., Berlin, 1890, p. 257.

"The question whether *Hylonomus*, and especially whether *Petrobates*, is to be classed with the Stegocephala or with the Rhynchocephala, is not one which can be at once decided. The long, bent, trunk ribs, the marking off of the cervical section by short differently-shaped ribs, the rhombic horned episternum, the bony pubica, the ossification of the carpus and tarsus taken together give both quadrupeds a reptilian habitus. In the case of *Petrobates* this becomes more pronounced by the occurrence of ventral ribs and of intercentral lower arches dovetailed in between the vertebral centres of the neck. On the other hand, *Hylonomus* and *Petrobates* have, like the Amphibians, only one sacral vertebra. A more primitive habitus is also presented in the persistence of the continuous chorda, in the insignificant superficial ossification of the elements of the skeleton, the absence of ossification in the heads of the hollow bones of the extremities,[1] and in the uniform shape of the small teeth.

"In *Hylonomus* this becomes strengthened by an apparently true stegocephalic skull-cover, as well as by the thick comb-like development of teeth in the roof of the mouth, and the presence of a ventral shield of bony scales.

"These several points of resemblance connect *Hylonomus* (*Hyloplesion*) rather with the Stegocephala, while *Petrobates*, on account of its ventral ribs and intercentral arches, comes nearer the *Rhynchocephala.* In other words, they both possess a general, as yet but slightly differentiated, common habitus, but in *Hylonomus* (*Hyloplesion*) the primitive type is more pronounced than in *Petrobates*, in which already a great specialization in the direction of the Rhynchocephala finds expression. If one, in considering *Petrobates*, disregards the skull, which is not accurately enough known, one might hold this quadruped to be a small Rhynchocephalian, of the family of the Proterosauridæ, if it were not that the presence of only a single sacral vertebra was opposed to this view. It appears as if *Hylonomus*, *Petrobates*, *Palæohatteria*, and *Kadaliosaurus* belong to a natural group of contemporaneous quadrupeds, representing however as many stages of specialization in the direction of Reptiles."

Bearing in mind that the typical species of *Hylonomus*, represented by *H. Lyelli*, are in some important respects nearer to *Palæohatteria* and *Kadaliosaurus* (which are regarded by all palæontologists as generalized reptilian genera tending to Amphibians) than either *Hyloplesion* or *Petrobates*, this conclusion of Credner becomes very significant as to the position of the Microsauria, and may be regarded as confirmatory of the conclusions which, though not a specialist in fossil reptilia, I have ventured to suggest in connexion with the species which I have been induced to study, in consequence of their connexion with my other work in Carboniferous geology.

It must be remembered that the repositories in which *Hylonomus* and its companions are contained are of an exceptional nature, and likely to have entrapped animals specially terrestrial in their habits.

[1] These characters do not apply in so great degree in *Hylonomus* proper.

I have elsewhere[1] referred to the fact that even in the basal beds of the Carboniferous (Horton series) there are footprints of quadrupeds of larger size than *Hylonomus*, which were digitigrade, and had a length of stride comparable with that of modern carnivorous mammals. I therefore anticipate the discovery, in these Lower Carboniferous beds, of reptiles of as high or higher grade than those hitherto found in the Coal-formation or Lower Permian, throughout which periods the same or similar forms seem to have prevailed.

II.—ON THE VERY RECENT AND RAPID ELEVATION OF THE HIGHLANDS OF EASTERN ASIA.

By HENRY H. HOWORTH, Esq., M.P., etc., etc.

(*Concluded from our last Number, p.* 104.)

THESE opinions of Mr. Campbell, however clearly and precisely stated, are so strong and emphatic, that I wish to confirm them by those of another experienced geologist, who worked much among the Himalayas, namely, General McMahon. In "Notes of a Tour through Hangrang and Spiti," published in the twelfth volume of the Records of the Geological Survey of India, he describes the existing glaciers and their remains in the district, and then says: "I do not know whether any one has ever supposed that the Himalayas were covered during the last Glacial period with an ice-cap, but I may note that whilst I saw nothing to favour such an idea, I saw much to negative it. The contour of the hills and valleys in those parts of the interior of the Himalayas that I have visited is sharp and angular, and where rounded outlines are seen, they are sufficiently explained by the action of subaerial forces on comparatively soft and friable rocks.

"But setting aside the idea of an ice-cap, the question remains—Was there formerly any great extension of local glaciers, and if so within what limits? To this question I answer that, whilst I saw evidence of the former extension of existing glaciers, I saw nothing during my tour to lead me to believe that these glaciers had ever, within a reasonable geological period, extended lower than 11,000 or 12,000 feet above the sea.

"On looking down from a high vantage ground, deep narrow side valleys may be seen on the Upper Sutlej, below that level, in which the course of the streams flowing through them is so sinuous that the sharp headlands formed by their sudden bends interlace like the nuts of cogwheels working into each other. The flow of ice in a glacier being analogous to the flow of water in a river and its tributaries, a grand glacier filling the valley of the Sutlej would not have prevented the flow of ice from the side glaciers into the main glacial stream. But had these side valleys ever been filled with glaciers, the sharp interlacing headlands would have been gradually worn down to smooth surfaces, and the valleys straightened and widened. The only valley in the Himalayas I have yet seen that is shaped like a glacier valley is the Spiti valley. The greater part of it is 11,000 feet above the sea, and its bottom, especially in the upper part of the valley, is broad and flat, while the bounding mountain sides rise abruptly in a wall-like manner at a high angle, and send no sharp projecting spurs into the valley" (*id.* p. 68).

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[1] Trans. Roy. Soc. part ii. 1882, p. 653.

Lastly Strachey, a very judicial observer, says, writing in 1880, "Till now no geological evidence has been adduced to indicate in this region anything corresponding to the Glacial epochs of Northern Europe, to which these former extensions of the glaciers could be attributed" (Ency. Brit. vol. xi. p. 831).

The evidence from the Himalayas must therefore be taken as proving emphatically the absence of anything like the glacial phenomena of Europe there. Notwithstanding the enormous height of that range, and its consequent efficiency as a condenser, and notwithstanding its close presence to a great sheet of water in Central Asia now dried up, it shows no traces of that great growth of glaciers which marked the same period in Europe and North America. I have no other explanation to give save and except the one I offered in regard to the similar phenomena in the Ural chain, namely, that this great mass and congeries of mountains was then non-existent.

If we turn to another kind of evidence, namely, that of the salt lakes, which are found scattered over the vast area occupied by the Highlands of Eastern Asia, we can scarcely escape the conclusion that they have formed within a not distant period a more or less continuous sheet of water, perhaps connected with the sea which once occupied the Uralo-Caspian depression. Humboldt reports a Mongol tradition that the part of the Desert of Gobi towards Erghi once formed the bottom of a sea more than a hundred leagues in diameter. The district is strewn with salt lakes, and the saline plants growing there are of the same species as the plants growing on the borders of the Caspian (Humboldt, Tableaux de la Nature, vol. i. pp. 95–97).

The Chinese reports about the country of Lob Nor are to the same effect, and are probably based on an induction from its physical appearance. Valikhanof says of Kashgaria: "The interior of the country is a sandy desert, the peculiar features of which first become visible in the eastern slopes of an undulating range of hills, of no great width, between Yanyshahr and Yarkand. From this region it gradually widens as it runs to the eastward, where it forms the vast Gobi devoid of all vegetation, though interspersed with reservoirs of brackish water, and where the sand is heaped in such lofty ridges that the inhabitants give them the name of Gag (mountain). The parts that lie at the foot of the mountains have a clayey soil, strewed with small stones, and in some places impregnated with salt" (Michell's Essays on Central Asia, pp. 110–111).

"There are many lakes in Little Bokhara," says the same writer, "all lying along the borders of the inner desert, and containing brackish water" (*id.* p. 118). Dr. Stolizcka, who accompanied Sir Douglas Forsyth's mission, speaks of the entire soil in the valley of

Kashgar as being very saline. South-east of Taitma a large quantity of pure salt in cubical crystals is collected, and he adds, "The fact that there is such a large quantity of saline matter together with salt swamps in the southern part seems to prove that the Jilga at least, and probably most of the others, had been washed out by the sea, and that while others had gradually, though only partially, drained off the saline matter, this one retained it, because it has at present no outlet. It is in fact a dried-up saline lake, which at some remote time was cut off from the sea of which it was a fiord" (Report of a Mission to Yarkand, pp. 472–473).

Richthofen, speaking of this wide plain, says, "It is girt round by a wide semicircular collar of mountains of the loftiest and grandest character, often rising in ridges of 18,000 to 20,000 feet in height, while the peaks shoot up to 25,000 and even 28,000 feet. The basin which fills in the horse-shoe-shaped space inclosed by these gigantic elevations, though deeply depressed below them, stands at a height above the sea varying from 6000 feet at the margin to about 2000 in the middle, *and formed the bed of an ancient sea*" (see "from Kulja to Lob Nor," by Prejevalsky, translated by Morgan, p. 138). Speaking of the Tarim River, the same geologist says: "The region through which it flows is highly charged with salt, springs of sweet water are rare, and only appear on the border of the mountains. Even in the high mountains the basins mostly contain salt, and in many valleys of the Altyn tagh, at a height of 11,000 feet, Prejevalsky found the water brackish. The water of the Tarim must therefore contain a larger proportion of salt than any other of the larger rivers of the world; and the unusual amount of evaporation must have produced a very large deposit of steppe salts of all kinds. The Chinese from ancient times have called the Lob Nor *the* salt lake in contradistinction to many other salt lakes" (*id.* p. 145). While Prejevalsky contests somewhat this evidence about Lake Lob, or rather explains it, he speaks continually of the saline character of the soil in the district he traversed.

Turning to the extreme west of the great plateau, Henderson's narrative of the journey from Lahore to Ladakh, p. 88, gives an account of the Karakash river valley. He speaks of depressions in the soil half full of brine, and some covered with a thick crust of common salt. He adds that the water of the Karakash contains salt, and Mr. Shaw told him that in winter it is like brine and quite undrinkable, and that the whole valley abounds in saline efflorescence (*op. cit.* pp. 88–89). Again, he speaks of the valley of the Chang Chenmo River as being, in certain places, all covered with saline efflorescence, and near the springs as smelling like decayed seaweed (*id.* p. 73). In the neighbourhood of Lungdung, again, he refers to efflorescence consisting of Epsom salts covering the plain, and in some places to a depth of many feet. Where springs exist they formed briny lakes, and clouds of salt are raised by the wind. The Pangong lake is about a hundred miles long from East to West. Each gallon of water contains 1000 grains of salt. And so I might continue.

If we go to the other extremity of the great plateau, namely, where it spreads out into the Desert of Gobi, we cannot read any traveller's report of its barren wastes scattered with salt lakes without coming to the same conclusions about it. Reclus describes it in his picturesque language: "The Gobi," he says, "like the Sahara, was formerly covered by the waters of the ocean, even on the elevated plateaux, old cliffs may be noticed, the bases of which are worn away by the waves, and long strands of round shingle stretch around the area which was formerly occupied by a now vanished gulf" (The Earth, p. 100).

It thus appears that the surface of the plateau inclosed by the great mountain ramparts of Asia bears continuous evidence of being the very recently (geologically speaking), desiccated bed of a sea, that is, bears witness to a very recent and wide upheaval.

Evidence that great masses of water have passed over the ground quite recently is forthcoming in the sheets of auriferous gravel containing the bones of the big mammals which are strewn over the flanks of the Altai in precisely the same way that they are over the Ural mountains, and necessitating the same conclusion; and the very wide-stretching mantle of shingle which Drew and others describe as covering large parts of the plateau of Ladakh, etc., seems to point the same moral.

Speaking of the beds in the elevated valleys of the Himalayas, Strachey says: "As in the case of the plain of India, we here, too, have no complete proof of the origin of these great nearly horizontal deposits; but it seems clear, from the materials of which they are formed, that they must have been laid out by water, either by the sea or by some great inland lake. They are largely composed of boulder deposits, and large boulders are strewn over the surface imbedded on the ground in a manner that seems only explicable as the result of the action of a considerable body of water (Ency. Brit. vol. xi. p. 828).

Again, the researches of Père David on the mountains separating China and Mongolia agree with the remarks of Stolizcka about the Kashgar country and of the authors of the Manual of Indian Geology, that the rocks themselves bear testimony to very recent disturbance on a large scale in this area; and following in the wake of Medlicott and others, Strachey says, "The general conclusion that may be drawn from the facts of structure thus briefly indicated is that the elevation of the Himalaya to its present great height is of comparatively recent occurrence" (Ency. Brit. vol. xi. p. 828).

The same view is maintained by Mr. Lydekker in regard to the outliers of the Himalayas, known as the Siwaliks, the upper beds of which belong to Pliocene, if not later times. He says, "In all the Jamu district, at all events, the Siwalik strata are carried up and contorted by the conformable underlying rocks; it is evident that these older rocks have only been raised at a comparatively recent period to the elevation at which we now find them, and that consequently in Siwalik times the whole of the outer belt of the Himalaya must have been much lower than at present." In another paragraph, speaking of the Siwaliks, he says, "Even their topmost beds are contorted and crushed in every conceivable manner, indicating the lateness of the period down to which the upheaval of the Himalaya has extended" (Records Geol. Survey of India, vol. ix. p. 100).

But we have evidence which is still more striking, and which seems to me to point conclusively not only to the upheaval having been recent but rapid.

Buckland, in his Reliquiæ Diluvianæ, speaks of certain bones of Horses and Deer procured by Captain Webb from the Chinese Tartars of Daba, who assured him that they were found on the north face of the snowy ridge of Kylas, in lat. 32°, at a spot which Webb calculates to be not less than 16,000 feet above the sea-level. They are only obtained with the masses which fall with avalanches from the region of perpetual snow, and are said by the natives to have fallen from the clouds and to be the bones of genii. Their medullary cavities and cancelli were lined or entirely filled with white crystalline carbonate of lime, beautifully transparent, the bone being white and very absorbent to the tongue. With them were found the bones of Bears. The discovery of these bones in such a situation, amidst perpetual snow, and quite out of the habitat of Deer and Horses, naturally attracted Buckland's notice. He urged that they are carcases of animals drifted to their present position by diluvial waters (Rel. Dil. pp. 222–223). They seem to me to evidence very plainly the fact that the Himalayas have been very greatly elevated since the bones were deposited.

The instance quoted by Buckland does not stand alone. Strachey called attention in the seventh volume of the Journal of the Geological Society to the presence on the very high land forming the watershed between the upper streams of the Ganges and the Sutlej, at a height of from 4200 to 4800 metres above the sea, of beds of sand, gravel, etc., containing a multitude of bones of Horse, Ox, Deer, Rhinoceros, Elephant, etc. Writing quite recently he says of these remains, "The existence of the animals in the present condition of these regions would be wholly impossible; so that there is no room to doubt that these deposits have been raised from a comparatively low level to their existing great elevation of upwards of 15,000 feet, since they were laid out" (Ency. Brit. vol. xi. p. 828).

Again, Dr. Falconer, speaking of the Steppe of Hioondes between the Himalayas and the Kailasa range, which is 15,000 feet above the sea-level, says: "The tract in the emphatic language of Batten is shrubless and treeless, a vast waste supporting a few furze bushes and a sprinkling of the most Alpine vegetation; and the climate is one of polar severity." On this steppe remains of fossil animals have occurred, and notably of the Rhinoceros, and Dr. Falconer observes: "It is very certain that no Rhinoceros of the present time could exist for a day in such a habitat; and if we suppose the Tibetan species to have been clothed with a dense fur like the Siberian species, the carcase of which was brought to Pallas from latitude 64° on the banks of the Lena, still the tract could never have subsisted it. . . . . ." In the case of the Rhinoceros the incisor teeth are deficient in number, and the greater portion of them rudimentary in form, and even deciduous. It may, therefore, be very safely predicated of all the species, fossil or existing, that they could never subsist by browsing on a herbaceous vegetation; they want *the nippers* which enable the Horse and Ruminants to subsist on low grass; and their food must either be derived from large reeds, shrubs or trees, none of which are now found in Tibet" (Memoirs vol. i. p. 180).

Again, speaking of Lyell's theory about the possible transportation of the Siberian Rhinoceros, Dr. Falconer says, "But these conditions will not apply to the Hioondes; the Rhinoceros could neither have migrated to its mountain-locked plain, from the side of Hindostan by the passes where men and goats can hardly find their way save by the artificial aid of scaffoldings, nor is it apparent how they could have been transported to their present resting-place from a higher tract" (Mems. p. 180). He then goes on to postulate an upheaval on a huge scale of the whole Himalayan range since the Rhinoceros was living there.

In support of Dr. Falconer's view about the impossibility of a large herbivorous fauna having lived in these high valleys under present conditions, I should like to quote Mr. Drew, who was very familiar with the plateaux of Ladakh. He says, "Vegetation exists but here and there; generally every ten or fifteen miles is to be found some *burtse* or Eurotia, the plant that serves for fuel, although at one halting-place moss is obtained in its stead, and at another neither *burtse* nor moss can be got. Pasture is still rarer; on leaving the last halting-place in the Chonglung branch of the Chāngchenmo valley, we had to pass over 60 or 70 miles before reaching any grass; the first find was at Lokzhung, a halting-place in the middle of the mountains of the same name. On the Kuenlun plains grass is equally scarce. . . Of wild animals one would think from the footprints that great numbers must live in the plains and the surrounding mountains; but one sees few, and on reflection it appears that the many footprints are the work of a comparatively small number of individuals, for in this country a mark may stay unobliterated for years" (Jummoo and Kashmir Territories, p. 352).

Recently (Records Geol. Survey of India, vol. xiv. part 2), Mr. Lydekker has discussed these remains, and arrived at a different conclusion to Dr. Falconer; but I confess I cannot follow his reasoning. He once deemed them to be of Siwalik and not of Pleistocene age. He now admits they are of the latter period, Mr. Griesbach having found the beds from which they came, and found them lying horizontally upon highly-tilted Tertiaries, which are presumed, says Mr. Lydekker, to correspond with some members of the Siwalik series of the outer hills.

Their age being unquestioned, Mr. Lydekker objects to the beds having been raised since they were deposited to the extent of 15,000 feet, because they are horizontal. A few paragraphs further on he allows that he would not have been surprised if the elevation had been only 1500 feet, and he further adds that "the possibility of such a minor elevation is countenanced by the fact that the Pleistocene lacustrine strata of the valley of Kashmir have undergone a considerable amount of disturbance." This means, I presume, that beds will maintain their horizontality if raised up 1500 feet, but not if they are raised 15,000. To me the very reverse of this seems to follow. An elevation of 1500 feet means that the force probably operated over a small area and would cause a great deal of local disturbance. An elevation of 15,000 feet operating over the immense area covered by the highlands of Eastern Asia would mean the possible and probable raising of large areas without disturbing their horizontality.

Nor can I understand another argument of Mr. Lydekker's, namely, that there were probably some considerable sheets of water in Tibet which would modify the climate considerably, and make it possible for these large herbivores to live there at the present altitude. That the presence of more water would modify the climate is certain, but assuredly not in the direction Mr. Lydekker urges. Water at 15,000 feet above the sea-level would feed glaciers and not trees. The reason why the present Himalayan glaciers are so shrunk is, it seems to be entirely due to the desiccation of the country, and if there were only watery vapour to condense, the Himalaya valleys, 15,000 feet above the sea-level would assuredly condense it fast enough. This is the very reason why the glaciers are so much higher on the northern flanks of the Himalayas at the present moment than they are on their southern slopes. As Thompson long ago said in his admirable book, "In comparing the glaciers of the Tibetan Himalaya with those on the Indian face of the same mountains, it will be found that *cæteris paribus* glaciers descend much lower on the Indian side, or in a moist climate, than in the dry and arid Tibetan climate" (*op. cit.* p. 580).

We may take it, therefore, as certain, that if present conditions are incompatible with the existence of a varied herbivorous fauna, those postulated by Mr. Lydekker must have been much more so, and it seems to me that Dr. Falconer's argument remains absolutely intact, or is rather strengthened by Mr. Lydekker's. It is strengthened also by a fact long ago noticed by Thompson and Cunningham.

Thompson, in his Travels in the Western Himalayas, more than once mentions finding fresh-water shells in lacustrine clays at great heights; *ex. gr.* at Kyuri he found a few small shells, among others a *Limnæa* and a *Planorbis*. The clay was covered by a coarse alluvial conglomerate (*op. cit.* p. 117). Again near Lake Thogji Chumo, he found shells in prodigious abundance. This was 15,500 feet about the sea-level. A day's journey further on he again met abundance of shells in the clay, nearly all *Limnæa*, but occasionally there was a small *Cyclas*. The lake, which is now salt, must, Thompson urges, have been fresh when these molluscs lived in it (*id.* pp. 170–2). Again, at the lower part of the Nubra, about 10,300 feet above the sea-level, he again found the shelly clay covered with some fifty feet of detritus. The shells, he says, which were all small, were species of *Planorbis* and *Limnæa*, apparently identical with those afterwards found in the neighbourhood of Iskardo, but quite different from those of the salt lake of Thogji (*id.* pp. 198–9).

Cunningham not only refers to the same fact, but explains it. Speaking of the former presence of wide sheets of fresh water in Ladakh, he says, "Their existence is further proved by the abundance of *fresh-water* shells that are found in the sandy clay deposits around the present *salt-water* lakes and on the dry plain of Kyang. These shells are of two kinds. *Limnæa auricularia* of all sizes and *Cyclas rivicola*, which is only found of very small size preserved in the interior of the larger shells. As these mollusca, says Cunningham, do not now exist in Ladakh at a greater elevation than between eleven and twelve thousand feet, it seems a probable conclusion that the country must at some former period have enjoyed a very much milder climate than that of the present day" (Cunningham, Ladakh, p. 193). That is to say, the level of the country must have been much lower.

The kind of evidence I have here adduced might be multiplied, but what I have quoted must suffice for the present, and to what does it testify with most converging emphasis? Assuredly to the conclusion that the great mountain masses of Eastern Asia, with the plateau they girdle and support, form a very recent feature in physical geography, and that the date of their upheaval was in all probability as late as the time when the Mammoth age came to an end, and when the remains of that great Elephant and his companions were scattered over the flanks of the Altai, and his contemporaries were entombed among the snows of the Hioondes valley in far-off Tibet. The evidence of this seems to me to be overwhelming, and it becomes still more so when it is not only found to be consistent with, but to alone explain how the former mild climate of Northern Siberia was converted into a very severe one, how the great Asiatic Mediterranean was drained of its waters and a large portion of its bed converted into the salt-incrusted plateaux of Tibet and Kashgaria, and how its drainage swept away the fauna of Northern Asia, and not only drowned the animals, but buried their carcases intact under continuous beds of gravel and clay over many degrees of longitude. Among the sympathetic readers of my Mammoth book there have been some whose judgment I highly prize, who have often asked me for a cause capable of such effects as I there postulate. In regard to those effects in Asia at all events, it will be admitted that, granting the validity of my induction, I have produced in this and recent papers, published in the GEOLOGICAL MAGAZINE, a cause which is competent and which explains all the facts. The argument of my book extended of course beyond the limits of Asia, and perhaps I may be permitted in another paper to apply the reasoning I have here employed to the Great Cordillera of America.

III.—FURTHER NOTES ON FIRECLAYS, ETC.

By W. MAYNARD HUTCHINGS, Esq.

THESE notes are in continuation of my former paper "On the Probable Origin of some Slates" (GEOLOGICAL MAGAZINE for June and July, 1890). Since its publication I have endeavoured to obtain a little further knowledge of the constitution of the fireclays of the Coal-measures, which I regard as so well calculated to throw light on the origin of many slates, and especially I desired to get, if possible, a little more evidence as to the supposed regeneration of mica in them, in connexion with the intimately associated question of the rutile-needles.

With this object I have tried to get as good a separation of the components of the clay as the very unfavourable nature of the material will allow, and this I have done by means of a rather prolonged and tedious course of what may be called "fractional levigation." This may be carried out in various ways, but the method I have found best suited is suspension of thoroughly disintegrated clay in water in large beakers, and syphoning off the suspended portion after appropriate periods of settlement.

The results of such levigation, though naturally very imperfect, still provide a material for microscopic examination from which some information may be had which could not so well be obtained from "sections" of clay, and which to some extent supplements and confirms what was formerly observed.

Taking again the fireclays of the Cliffs at Seaton, described in my former paper, about a cubic inch of the finest-grained bed was used. It was air-dried and crushed to powder, but not ground. It was then reduced to fine mud by crushing gently in a mortar with water, and finally left several days in water in a beaker, with frequent agitation, to insure as complete disintegration as possible. Preliminary trials showed that a sufficient degree of classification for my purpose was obtained as follows:—The whole was well stirred up in a beaker (11 inches deep by 6 inches wide) and two-thirds of the contents syphoned off after one and a half hours. This was repeated very many times till practically nothing more was taken over. The united material so obtained was again differentiated by suspension in water and drawing off after half an hour, and this second portion was again treated in a similar manner. Thus, three divisions of the first, finest, part were obtained, A, B, and C.

The residual original clay was next separated by repeated drawing off after 15 minutes' settling, and the portion drawn off was divided into two by a similar process, giving D and E.

The next stage was to draw off after two minutes' settling, and again divide the resultant part into two, giving F and G, leaving a final coarsest residue of the original clay, H.

Nothing is obtained from these fireclays at all approaching in fineness what is observed when fresh deposits, and some recent clays, are suspended in water; material which remains many days in suspension. Everything settles in a few hours, and such original fine slime is long since consolidated and altered into denser matter.

These various portions separated were collected by settling into smaller and smaller beakers, and finally, as thick mud, into stoppered bottles. They were mounted for examination by mixing some of the mud with a very little gum-water and painting very thin films on the slides with a camel-hair brush, drying, and covering with balsam and thin covers. With a little care even the finest portions could thus be got so that single flakes and grains could everywhere be examined.

The three finest portions A, B, C, under the microscope are seen to contain far away the largest portion of the rutile-needles of the clay. These are exceedingly abundant. The main portion of these finest slimes consists of very minute flakes, the smallest of which, especially in A, can only be seen when examined in water instead of balsam, many of the others being only seen in balsam by lowering the condenser very much. Without specifying anything further, it is safe to say that most, if not all, of this distinctly flaky material is micaceous; and as A, B, C make up a large part of the portion levigated, this very small micaceous substance is a leading component of the original clay. The larger bits are distinctly seen to have a greenish or yellowish tinge. Not a single bit can be seen which could for a moment be mistaken for biotite. In no case is any bit seen which *contains* rutile; the two minerals are here quite separate.

Micaceous ilmenite in small flakes, and little plates and grains of epidote, are rather abundant, also a good deal of matter too minute for any sort of identification. I cannot make out anything that could be safely referred to "Kaoline."

In the next grades, D and E, we of course get among larger-grained material, and here a considerable number of flakes are seen more or less full of rutile-needles. It was such flakes which I was specially anxious to isolate.

The first thing to remark about them is, that though they vary a good deal in size, the *upward* limit is pretty sharply marked off against the flakes which do *not* contain rutile; and when the next coarser grades of levigated material, F and G, are examined, this is again strongly emphasized. The number of rutiliferous flakes is much less than in D and E, and those present are largely due to the carrying over of one grade into another;—to the inevitable imperfection of the separation.

Considering then the whole of the rutiliferous flakes in D, E, F, G, those over $\frac{1}{1000}$th of an inch in largest diameter are rare, those reaching to that size are not a large proportion; the fairly average size of what might be called the larger flakes being about $\frac{1}{1500}$th of an inch across. From this downwards there are all sizes till a lower limit is reached, beyond which, as in A, B, and C, no *contained* rutile is seen.

If the flakes are studied in detail, it is soon seen that only some of the smaller ones are *single* flakes at all. Every larger one is seen, by its extinctions, to be an aggregate of more or less numerous smaller flakes overlapping one another, and with different optical orientation. The majority of these complex flakes have all their component flakelets lying flat in one plane; but some are seen, especially among the coarser material of F and G, which are more or less globular aggregates, in which the mica lies at all azimuths, those bits seen edgewise depolarizing very brilliantly.

I may here remark that when the same levigation-process was carried out with a coarser band of the Seaton clay,—the grade of coarseness next following the fine fireclay,—just the same results were obtained. A much less relative proportion of the finer material was obtained, of course, but what was got was similarly composed, and the limits of size of the rutiliferous flakes were the same.

Most patient search was made for flakes which might allow of tests in convergent polarized light; but not one could be found of sufficient size which was not complex, and therefore useless for that purpose. One or two "figures" which I thought I had obtained, in "sections" of the clays, from rutiliferous flakes, are therefore very doubtful and of no value; probably due to original muscovite imperceptibly mixed in with the secondary minerals.

The same difficulty occurs in examining slates. Not in the thinnest parts of the thinnest sections it is possible to make have I ever succeeded in finding a single simple flake of the rutiliferous mica. It is all a felted complex of small flakes, exactly similar to the larger of the complex flakes in these clays.

The study of A, B, C, in conjunction with the coarser grades, leaves no doubt on one's mind that the bulk of the material of the former results from the disintegration of the complex flakes and globular aggregates described; the rutile lies mainly in between the minute component flakelets, and is set free when these are detached, except in relatively few cases of larger single flakelets.

There will also doubtless be present in the finest slimes more or less of minute flakes of original muscovite, though most of this mineral in this fine state of division has, I think, been absorbed into the new combinations.

In all the coarser grades there is present a good deal of original clastic muscovite, much more than would be supposed from examination of *sections* of clay, where much of it is hidden. All this muscovite is perfectly colourless and clear, and free from any trace of rutile. The supposed secondary mica is all very distinctly coloured, mostly yellow, sometimes greenish, and larger flakes are more or less turbid.

Flakes of altered biotite are also not scarce, now that levigation has set them free. They are relatively large, easily recognized, still considerably active in polarized light and dichroic when seen edgewise, but flat sections are all quite inactive in convergent light, being all more or less advanced in the process of waste and bleaching, with the same formation of epidote, etc., as described in the coarser material in my former paper.

No such flakes which can be identified as biotite in any stage of decay contain any rutile whatever.

There is nothing special to remark about the other minerals in these coarser parts of the levigated clay. Quartz and felspar grains appear,—the latter scarce,—all completely rounded and many carrying more or less a skin of rutiliferous "paste," in spite of all the washing and agitation. I think it is really corroded on to the substance of the grains in many cases. A few beautiful little crystals of anatase, both pyramidal and tabular, are not missing.

Looking at the facts stated, the one which appears to have most bearing on the main point concerned is the pretty strict upward limit of size of the rutiliferous flakes.

If we suppose the rutile-needles to have been contained, as such, in the original clastic material as it was deposited in these beds, then we should find no such limit of size. If the rutile were contained in the micas, for instance, we could not well find any reasoning to explain why only flakes up to a certain small size should be rich in it, while those of larger size, from which the smaller ones *must* have been derived (on the supposition that what we now see is all primary deposit), should be absolutely free from it. These rutile-needles are, as I have before maintained, the key to the whole question. Some writers have simply ignored them, others make very light of them. Thus Roth (Chemische Geologie, vol. ii. 1887, p. 586) doubts that any proof has been given of the authigenic origin of the rutile-needles in slates; and again in his latest volume (Allgemeine Geologie, vol. iii. 1890, pp. 169–170) returns to the subject and contests the views of Rosenbusch and Lossen as to the secondary origin of the colourless mica of clay-slates, dealing with the rutile-needles by saying that "separation of the titanic acid of weathered micas as rutile is often enough observed."

As regards this supposition, that the rutiles in question in these fireclays may be due to any simple weathering of biotite, the same argument as to the size of flakes appears again to be difficult to answer. We might, perhaps, say that the larger the flakes the less they would be susceptible to such weathering. (This is not the case with the process of decay of biotite, pure and simple, as described in my former paper. The large flakes suffer as much as smaller ones. Nor does it seem true of biotite in any sort of weathering; chloritization, for instance. Big flakes are attacked as easily as little ones, the extreme fissility apparently counterbalancing the greater size.)

But even on this supposition no approach to a sharp line would be seen; the diminution of the amount of weathering and of the resultant rutile would be more or less gradual in proportion to size. Of course we know that biotite does sometimes give rise to rutile directly during weathering. What are the conditions, either in the original biotite or in the method of weathering, which cause this, we do not know; but we do know that it is relatively rare compared with the universal weathering of biotite *without* any formation of rutile.[1]

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[1] In those cases where the separated rutile is arranged in approximately hexagonal star-forms, more or less conformable to the symmetry of the containing mica, I consider that it is due to other causes than weathering, viz. sometimes to original crystallization, but more often to powerful dynamic action, and that it is in the same category as the symmetrically arranged rutile in some micaceous ilmenite, and in sagenite.

But in these deposits, derived from granite-waste, the biotite is clearly seen not to give rise direct to any crystals of rutile, any more than it does in most granites, etc., where it is undergoing decay *in situ*.

The effect on my own mind of studying the slates, passing from these to the fireclays and associated shales (for reasons formerly stated), and back again to the slates, having approached the matter without any bias one way or other, is that I cannot come to any other conclusion than that the main mass of mica,—all the rutiliferous mica,—of the slates is a new formation, posterior to sedimentation; that in the fireclays and shales the same thing has commenced and progressed in the same manner up to a certain stage; and that most of our slates were produced from deposits of closely similar nature by a continuation and intensification of the conditions involved.

I must thank Dr. Irving for his very kindly and encouraging remarks (in the GEOLOGICAL MAGAZINE for December) concerning the value of my little study of the clays, etc., but I do not think I can quite follow him in the conclusions he draws.

For one thing, will it be quite safe to say that the fireclays of Northumberland (or any other Carboniferous clays and shales) have undergone no dynamic metamorphism whatever, even though what has taken place did not suffice to alter the deposits into hard cleaved slates?

It has suggested itself to me that possibly the more or less close association of these beds with the yielding coal-seams may have largely tended to preserve them from any of the severer effects of pressure, etc.;[1] but I am quite inclined to think that we are justified, on geological evidence, in assuming that they have taken part in conditions which could well be classed as "dynamic."

If I have, as Dr. Irving says I have, "simply ripped up" the idea of the "dynamometamorphic" origin of the secondary minerals in slates, I can only say that I had it not in my mind to do this savage and gory deed at all. If I have done it (which I do not see), then I am in the painful position of having unintentionally ripped up a friend, for I certainly believe that the completion of the regeneration of the materials of the deposits resembling the fireclays, and their formation into slates, was the result of very severe "dynamometamorphic" action and could not be brought about, as regards the coarser parts of the deposits, without its aid. Still, these are only "views," and nobody's views are of very much authority in the present state of our knowledge of these matters. We want, perhaps, more facts and less views. My excuse for stating mine above must be my desire to escape some remorse for the thing Dr. Irving says I have done!

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[1] It is stated in works on geology that the "underclays" of the Coal-fields are *unstratified*, and though I am not aware that this is so uniformly the case as to allow of its being given as a universal rule, still it is no doubt true enough when taken as referring to the clays occurring with workable seams of Coal. It is not by any means so as regards beds of exactly the same materials which occur in the same Coal-fields, either without any immediate connexion with Coal-seams, or only with very thin seams, far too thin to work. This unstratified condition of many fireclays is probably due simply to the crumpling and crushing they have undergone in connexion with the compression of the materials out of which the Coal was formed. It is also, no doubt, quite true as stated in the book (first suggested by Sterry Hunt), that Clays on which the Coal-vegetation actually grew were deprived of much alkali by the plants. It is therefore more desirable in studying these deposits, as bearing on the origin of slates, to select beds which have not had the stratification disturbed and which have no Coal in actual contact. This is the case with the beds at Seaton Cliffs, which I have used so much as my principal type and source of material.

I may mention that since my first paper I have examined clays and shales from the Derbyshire coal-field (Clay Cross), and with the same results. Materials from all the coal-fields seem to be of like nature, derived from the same or a similar source,—a granite (or gneiss?) with two micas, biotite being in excess.

As regards the composition of all these fireclays, I would once more emphasize the fact that they are *not* "hydrous silicates of alumina." The results of chemical analysis chance to lend themselves tolerably easily to this interpretation; but it is quite a wrong one. The analyses are quite as well suited to a material mainly composed of strongly hydrated altered micas. Writers dealing with fireclays seem to have thought that every chemical analysis must be worked up into a "formula," just as is done so much in the case of metallurgical slags, even though in both cases a glimpse through the microscope would show the complexity of the substance and the uselessness of the formula.

WOODWARDIAN MUSEUM NOTES.

IV.—ON VARIOUS CRYSTALLINE ROCKS.

By ALFRED HARKER, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

(i.) *Pyroxenite (Websterite) from Fobello, Lombardy.*

CRYSTALLINE rocks containing neither felspar nor olivine have received but little or no attention, except from one or two American geologists. Dr. G. H. Williams[1] has recently drawn attention to these rocks, of which he proposes to constitute a family of Pyroxenites coördinate with Rosenbusch's family of Peridotites; and has described from Maryland and North Carolina a type consisting entirely of monoclinic and rhombic pyroxenes, to which he gives the name Websterite. The occurrence of a similar rock in Northern Italy seems worth recording. Our specimens were collected by Mr. E. J. Garwood.

To the eye the rock appears as a coarsely crystalline aggregate of lustrous black diallage, in which the rhombic pyroxene which forms the second constituent is scarcely to be distinguished. The specific gravity of the rock is 3·229.

A slice [1086] shows the rock to consist of large plates of diallage moulding smaller grains of hypersthene, neither mineral having any external crystal form.

The hypersthene is the first-formed mineral, and builds irregular crystal-grains up to one-tenth of an inch in diameter, showing marked pleochroism in pink and green tints. Cleavages parallel to the two pinacoids occur, in addition to the usual prismatic cleavage. There is often a minute "schiller" structure, apparently parallel to the brachypinacoid, besides larger inclusions, which have the same orientation, and appear to be of the nature of rhomboidal cavities filled with some dark brown ferruginous material. The absorption-colours, so far as can be made out in random sections, are, parallel to

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[1] American Geologist, July 1890.

α=a ... rose-pink;
β=b ... nearly colourless;
γ=c ... pale apple-green.

The diallage is in colourless, irregular plates, often slightly bent. It shows rather broad bands following the orthopinacoidal parting and corresponding to the "solution-planes." These bands are occupied sometimes by a colourless and highly birefringent crystalline mineral like calcite, sometimes by brown or greenish-brown matter. There is a strong cleavage always making a high angle with these bands and probably parallel to the basal plane; this, too, seems to be a direction of chemical weakness, though a less marked one. Less pronounced cleavages correspond, no doubt, to the prism-faces.

The only other mineral which can be considered original is a deep brown, pleochroic hornblende, which occurs rarely, in small scraps, intergrown with the diallage near its contact with the hypersthene. There is no trace of felspar or olivine, nor any original iron-ores or other accessory minerals.

Though often quite fresh, the hypersthene sometimes shows alteration into a minutely granular aggregate which gives high polarization-tints. The change begins in veins following cleavage cracks, but may destroy the whole of a crystal, so that nothing is left of the original structure of the hypersthene except the dark-brown schiller-inclusions mentioned above. Into the spaces thus occupied by the obscure alteration-product, project jagged fringes of colourless, brightly-polarizing hornblende, which, although formed at the expense of the rhombic pyroxene, grows as an extension of the diallage, towards which it is oriented in the usual crystallographic relation.

(ii.) *Eclogite from Port Tana in the North of Norway.*

This rock, collected by Mr. R. H. Solly, shows in a hand-specimen plenty of red garnets imbedded in a yellowish-green crystalline mass in which pyroxene (omphacite) is evidently the dominant constituent.

In a slice [962] the garnet shows an irregularly rounded outline and a faint pinkish tinge. Some of the crystals are distinctly double-refracting. This character is not associated with any polysynthetic structure, and may be due to internal strain; it is sometimes more marked in the vicinity of certain inclusions. A constant feature is the presence of countless minute rods accurately alligned in three directions parallel to the three crystallographic axes. They belong to a clearly double-refracting mineral, and give extinction-angles up to about 31°. This agrees with disthene or cyanite, a mineral described by Riess[1] as a common constituent of eclogites. Among the other minerals included by the garnet may be mentioned quartz and apparently omphacite, mostly in round granules clustered in the centre of the crystal; zircon, commonly in little well-formed crystals, bounded by the pinacoids (100) and pyramid (111); and locally, near the margin of the garnet, crowds of little prisms with moderate double refraction and sensibly straight extinction, possibly zoisite. Some larger rounded grains of quartz containing little zircons are inclosed near the border of the garnets, and occasionally a small flake of brown mica. Larger flakes of mica, with strong pleochroism, occur in densely-packed bundles moulding the surface of the garnets.

The rest of the rock consists chiefly of a crystalline granular aggregate of colourless omphacite and clear quartz, the latter giving 'undulose' extinction, and often crowded with the straight hair-like rods usually referred to rutile. This aggregate, however, incloses numerous idiomorphic, though rather rounded crystals of enstatite with a longitudinal striation and strong cleavage. There are also a few scattered rod-like crystals of reddish-brown colour, and not more than a tenth of an inch in length. These belong to a uniaxal mineral with exceedingly high double-refraction and slight, though distinct, dichroism ($E > O$). It is evidently rutile, a mineral not admitted in Riess' monograph, but recorded by Möhl[2] in some of the Norwegian eclogites. The crystals are simple tetragonal prisms, either (110) or (100).

(iii.) *Garnet-Amphibolite from Sutherland.*

The locality is three miles south of Laxford Bay. The rock shows abundant red garnets imbedded in a mass of greenish-black hornblende. A curious feature is the well-marked series of parallel cracks by which the garnets are traversed. These maintain a constant direction throughout the specimen, but do not affect the hornblende. They are evidently due to stress in the rock, and, though better developed, are of the same kind as the cracks seen in the garnets of various crystalline rocks, such as the Eddystone gneiss and some of the Saxon granulites. These cracks are always at right angles to the direction of 'stretching' in the rock, and so perpendicular to any foliation or schistosity that may be present.

A slice [1254] shows the rock to be composed chiefly of garnet and green hornblende. The garnet retains its red colour, and shows well the series of parallel cracks preserving a common direction throughout the slide. There is a less pronounced system of cracks roughly perpendicular to the first. The crystals are of irregular shape, but tolerably free from inclusions. They show no double-refraction, nor does the rock as a whole present any trace of foliation or other parallel structure.

The hornblende is in rude columnar crystals without terminal planes, and often so massed together as to prevent their free development. It constitutes nearly half the bulk of the rock. The colour is an intense grass-green, the absorption being, parallel to a yellow-green, β and γ deep grass-green, almost opaque. The extinction-angle $c\ \gamma$ is high, perhaps as much as 20°, but cannot be determined precisely owing to the strong absorption.

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[1] Tsch. Min. u. petr. Mitth. 1878, vol. ii. pp. 165–172, 181–241.

[2] Nyt Mag. Naturvidensk. vol. xxiii. (1877), pp. 128–137.

The other constituents are little crystals of finely lamellated plagioclase, irregular grains of an untwinned felspar, apparently orthoclase, shapeless granules of opaque iron ore, and a little clear quartz occurring interstitially among the hornblende and other minerals.

(iv.) *Quartz-Diorite from Viti Levu, Fiji.*

This rock occurs in the cutting for a new road on the mountains to the south of the Wainamala valley, below Narokorokoyawa in the island of Viti Levu. It was collected by Mr. J. J. Lister during the voyage of the "Egeria" in 1889. It is a crystalline rock showing lustrous black crystals of hornblende, about a quarter of an inch long, and flakes of golden-brown mica, in a mass consisting mainly of felspar. The specific gravity is 2·778.

Sections [1256, 1257] show that the felspar is exclusively plagioclase, in idiomorphic crystals, in which the usual albite-lamellation is combined with Carlsbad and sometimes with pericline-twinning. A strongly marked zonary structure is apparent in polarized light, the extinction-angles being much wider in the interior than in the border. There is clearly a transition in each crystal from a thoroughly basic to an intermediate felspar. The hornblende, often twinned, is of the green pleochroic variety found in the syenites and most true diorites, and the mica (biotite) is brown with intense dichroism. These two minerals are often closely associated, and, for the most part, mould the felspar. Quartz occurs interstitially as the latest product of consolidation. The earliest-formed minerals are apatite and magnetite, which are enclosed by all the other constituents.

The specimens are quite fresh, and, as regards the mutual relations of the minerals, the zoning of the felspars, etc., agree well with some examples of the Banatite type of quartz-diorite, such as those from Hodrics near Schemnitz [1085] and from Ben Nevis [397], or some of the Banat rocks themselves. Wichmann,[1] in his account of the Fiji rocks, has described a diorite from near the same locality; but it is clearly of a different type, and he makes no mention of either quartz or mica.

(v.) *Uralitized Gabbro from Eua, Tonga Islands.*

This specimen, also from Mr. Lister's collection, is from a boulder on the east coast of Eua, but the position in which it occurs proves that it must belong to the island itself. The point is one of some interest, as Eua, like the rest of the group, appears at first sight to be built entirely of volcanic and calcareous rocks. The rock is a

[1] Tsch. Min. u. petr. Mitth. (n.s.) vol. v. p. 17; 1883.

moderately fine-grained cystalline aggregate, in which little patches of black hornblende are seen moulding the dull whitish felspars.

In a slice [1258] the felspar is seen to be a lamellated plagioclase in crystal-plates, idiomorphic towards the bisilicates, but interfering with one another. Some crystals have their zones of growth indicated by slight differences in optical properties. The wide extinction-angles point to a basic composition. The hornblende has a pale green-brown colour, with a fibrous structure. It is sometimes a mass of matted fibres, though more usually there is a common orientation throughout each plate. There is no doubt that the mineral is pseudomorphic after augite, and there is frequently an unaltered kernel of colourless augite in the centre of the uralitic aggregate. In places, however, the usual amphibole cleavage is seen, and this is accompanied by more pronounced colour and pleochroism. The only other prominent mineral is magnetite, in irregular patches, of later formation than the felspar, but moulded by the bisilicate. The structure of the rock points to a plutonic origin, the general characters being those of a gabbro rather than a diabase, though to some extent transitional.

V.—Notes on the Older Rocks of Finland.

By R. N. Lucas, B.A.

(*Continued from page* 299, Vol. VII. July, 1890.)

THE consideration of the Archæan rocks of Finland, as pointed out in a previous article,[1] naturally divides itself into two parts: I. The treatment of the stratified or foliated members of the series; II. That of the igneous or eruptive rocks. In describing the former, want of space compelled me to handle the subject in what I fear must be regarded as a very fragmentary manner. In addition I confined myself entirely to giving an account of the older members of the formation, omitting all mention of the younger schists, mica-clay slates, phyllites, etc., which go to make up what is in Finland regarded as corresponding to the Huronian subdivision. I did this from two reasons,—firstly, because I was personally better acquainted with the rocks in question; secondly, because it seemed to me that it is the problem of the origin, sequence and composition of the *older* members of the series which at the present day possesses most interest for the student of the geology of the Archæan, and in consequence is the one with regard to which the greatest divergence of opinion prevails. In the present article I propose to give a short account of the more important eruptive rocks of Finland; but before proceeding to do so, it would not, I think, be out of place to furnish a short *résumé* of the conclusions to which the study of the foliated Archæan rocks of the country has led me, and which I believe to be thoroughly supported by the data published in my former article. These are:—

1. The succession on which I especially insist, namely, commencing from the base—(1) Granite-gneiss; (2) Grey micaceous gneiss;

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[1] Geol. Mag. July, 1890.

(3) Hornblende-gneiss or eurite. This sequence corresponds with that which has been established by Gümbel in Saxony, by the official survey in Sweden, by Groth in the Central Vosges (Geog. Unt. des Reichslands), and recently by Prof. Bonney in Switzerland. A similar sequence does not as yet appear to have been established among the Archæan rocks of the British Isles; but this may be due to local causes or to its having hitherto escaped the notice of geologists.

2. That the Archæan rocks of Finland present a similarity—I might I think almost say identity—of structure and composition with those of all true Archæan territories, whether situated in Switzerland or Scandinavia, Canada or Saxony.

3. That though we meet with numerous instances of gneisses which have been crushed and contorted, we also find plenty of examples which show no evidence of excessive pressure, and are nevertheless in all respects typical gneisses. This is particularly the case with regard to granite-gneiss and hornblende-gneiss.

4. That many, if not all, of the crystalline limestones which occur apparently interbedded with granite and gneiss, and in some of which "Eozoon Canadense" was formerly asserted to occur, are not deposits but veins, and are properly speaking to be classed with pegmatites and metallic lodes.[1]

Such are, I think, the principal conclusions to which a careful examination of the Finnish Archæan rocks conducts. They may, I trust, prove of interest not only because they summarize the results of research in a distant country, but also because, owing to the similarity of the Archæan system at all points where it has been observed, they may be regarded without hesitation as applicable beyond the limits of the district from the study of which they have, in the first instance, been derived.

ERUPTIVE ROCKS.

In my former article I massed both foliated and eruptive rocks together under the general heading of Archæan. This procedure is both convenient and customary, but it must be understood that its adoption involves the making of assumptions only some of which are in accordance with facts, others being actually controverted by them. Thus to regard the crushed and foliated granites which are interbedded with the older gneisses as of similar age with those gneisses themselves is a view which, as far as I am aware, there is nothing to disprove. But to consider all the eruptive rocks which pierce the gneiss formation as of Laurentian or even Archæan age, is an opinion which it seems to me there is not only nothing to support, but even the strongest presumptive evidence to disprove. Examples of this are afforded by the rapakivi, which in Southern and Western Finland occurs penetrating older strata, and might, if it had only been observed in those two districts, be regarded as of

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[1] Instances in point are afforded by the limestones of Hoponsuo and Henriksnäs, in which the Russian geologist Pusirewski—one of the worshippers of "Eozoon" —formerly believed himself to have discovered the object of his adoration!

Laurentian age. In the neighbourhood of Joensuu, however, a rock corresponding in all respects to the rapakivi of the south and west, was discovered by Prof. Wiik contorting and dislocating Huronian slates and phyllites, and hence it has become customary to consider the rapakivi as a "younger" eruptive rock. The case of the diabases is very similar. No grounds could be advanced which would lead to the conclusion that the dykes and bosses of the north of Ladoga Lake (Wallamo) are much more recent than the Huronian period. But in the extreme west of Finland a strip of sandstone occurs which is usually regarded as Cambrian, and this sandstone is pierced by diabase dykes. There is a strong family resemblance between nearly all the Finnish diabases, and it would certainly not be a very violent hypothesis to look upon them all as approximately of the same age, *i.e.* Cambrian or later—how much later we cannot form even an approximate opinion, as in Finland there is a "Gonungagap" from early Cambrian to Quaternary times.

I now pass to the consideration in detail of the more important igneous rocks following the natural subdivisions of the subject, and commencing with a description of—

1. The Acid Eruptive Rocks.

Gneiss-Granite.—The base of the crystalline series we found to consist of the *granite-gneiss*—a rock in which coarseness of banding and indistinctness of foliation cause it to present a *superficial* resemblance to granite. In the gneiss-granite we have a granite which, through the influence of pressure, shearing-stress, or other causes, has assumed the appearance of a fissile gneiss, and which might be very appropriately termed a foliated granite. In many instances it appears to be the oldest member of the eruptive series; for in most cases where it is pierced by unaltered granite, the latter is plainly a younger rock. I think, however, it would be incorrect to assume that all gneiss-granites are of the same age, for I have seen plenty of evidence to make me incline to the opinion that gneiss-granite is in reality a *facies* assumed by granites which may differ in age. Among other reasons for thinking this to be the case, I may mention that I have most distinctly observed at least one case in which a boss of granite which was mineralogically homogeneous throughout, showed unmistakeable foliation near its edges, which became less distinct and finally disappeared on approaching the centre of the mass. This, I think, can only be explained by assuming that pressure and shearing-stress have made their influence more felt upon the exterior portions than upon the interior.

Statigraphically the gneiss-granite usually preserves relations of more or less intimacy either with the granite-gneiss or with the grey gneiss, running side by side with one or other of these rocks over considerable tracts of country. Its foliation always appears parallel to the strike of the gneisses—a fact which certainly favours the view that it was the same pressure which tilted the gneiss strata into their vertical position which produced the foliation of the granite.

That in spite of its foliation it is of eruptive origin is very well shown by the fact that where it has gneiss for its next door neighbour, the latter rock becomes impregnated with granite-magma, which, as the gneiss-granite is the only granite near, cannot have been derived from any other source. It is often said to pass into ordinary non-foliated granite of a mineral composition identical with its own. I feel very little doubt, however, that in many cases in which this is stated to have been observed, and which I have not myself seen, the facts are in reality similar to those in the instances I gave above, namely, that the whole mass is one granite, foliated externally, and losing its foliation inwards.

Cases occur in which the gneiss-granite is pierced to such an extent by bosses and veins of *massive* (unsheared) granite, doubtless of later age, that it becomes a matter of difficulty to decide which of the two rocks in reality predominates. This state of things prevails in the neighbourhood of the village of Nummis.

Petrographically the gneiss-granite consists, like ordinary granite, of quartz, felspar, and mica. The quartz and felspar are as a rule disposed quite irregularly throughout the mass of the rock, but the mica occurs in laminæ which show parallelism of arrangement, giving rise to a semi-schistose, at times fissile appearance. Thus the apparent foliation of the rock is due entirely to the mica, and if we could dissolve it out or eliminate it by any other means, we should as a rule obtain a structureless mass of felspar and quartz. It is consequently the mica which enables us to distinguish gneiss-granite both from ordinary massive granite and from granite-gneiss. In the former no order of arrangement whatever is observable among the minerals composing it. In the latter there prevails a certain parallelism of arrangement among all the minerals of which it consists, and this would still remain to be observed even if any one of them such as the mica were to be removed. In addition true gneiss nearly always displays more or less stratification which is entirely absent in the case of gneiss-granite, for the latter quite resembles typical massive granite in its petrological uniformity and sameness of colour over wide areas.

Occasionally a certain subsidiary parallelism of mica cutting the principal mica planes at an angle is observable. This appearance we may, I think, correctly attribute to secondary stresses—it is in fact the outward and visible sign of secondary cleavage.

There is also a curious variety of gneiss-granite in which the rôle ordinarily played by the mica is assumed by the quartz. In these cases the quartz individuals are found as a species of laminæ arranged parallel to the general direction of cleavage and contributing to it (Mantsila district). Where the quartz occurs in this manner, the mica no longer shows parallelism—on the contrary, the mica and the felspar are then disposed quite irregularly throughout the whole.

Rapakivi, Sheet No. 7.—The towns of Borgå and Friedrikshamn are situated in the Gulf of Finland, about 70 miles apart. A square erected upon a line joining the two would, roughly speaking, comprise the celebrated Rapakivi district of the South of Finland. The whole of this region is comparatively flat in character, consisting of round dome-shaped protuberances covered with wood and alternating with lakes and shallow valleys above the level of which they seldom rise to a distance of more than about 50 or 100 feet. With the exception of a few dykes and bosses of younger granite and syenite, rapakivi forms the fundamental rock throughout the whole of this district, and there is scarcely a hillock or elevation where it is not to be seen emerging from beneath the Post-Tertiary formations which frequently overlie it, and presenting to the view the large crumbling boulders from which the rock has derived its name—rapakivi meaning in Finnish rotten or crumbling stone. The aspect of these boulders is very peculiar, at times picturesque; on the weather-side they have not unfrequently crumbled away to what is obviously not more than half their original size, and the base of the rock is in consequence covered with a talus of weathered fragments of felspar quartz-grains, hornblende crystals, etc., among which the large egg-shaped balls of orthoclase, varying from about an inch in diameter to the size of the fist, are still to be found comparatively intact.

Petrographically rapakivi consists of an aggregate of quartz, orthoclase, biotite and hornblende—the last being always in evidence. The orthoclase varies from pink to brick-red, occurring as a rule in crystals of 1½in. to 2½in. long and 1in. to 2in. thick, with glassy principal cleavage often appearing as Carlsbad-twins, and forming the principal constituent of the rock. Owing to radial accretion, it often happens that the crystals assume the form of oblong spheres which occur notably in the neighbourhood of Elima. These large crystals of orthoclase are surrounded by a mantle of oligoclase of a yellowish-green colour turning white on weathering. The quartz crystals, which are smoky grey or white, average about ½in. in diameter. The mica, which is extremely black, is pretty equally distributed throughout the whole in the form of brilliant laminæ. The hornblende, which is black, occasionally turning somewhat green, occurs only in small quantities and in the form of short monoclinic prisms. The rock does not display the slightest tendency towards parallel arrangement of any of its constituents.

Rapakivi has been microscopically examined by H. Gylling, from whose report the following facts are taken.

"In addition to orthoclase and oligoclase, microclinic felspar also occurs, recognized by its peculiar structure and the fact that it extinguishes polarized light 14° to 15° from the edge between the clinopinacoid[1] and the basal plane. The microscopic examination further shows that the quartz crystals are sometimes fully crystallized out and contain water in minute cavities (fluid inclusions). Both hornblende and oligoclase are much weathered, the former occasionally being decomposed into calcite. As occasional constituents occur yellow and yellowish-brown prisms of zircon, red laminæ and needles of hæmatite, and black opaque masses of magnetite and titaniferous iron ore. Crystals of fluor-spar are also at times visible even to the naked eye."

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[1] It will be seen that microcline is here regarded as really monoclinic—an opinion with which I certainly agree.

Though as above pointed out the rapakivi is almost perfectly uniform in its characteristics throughout the district in which it occurs, a variety distinguished by comparative hardness and capacity for resisting the weather is also found, as a rule on the confines of the rapakivi region proper; for instance, in Morsköm, Perno, and Borgå parish, where, as also in Helsingfors, it is largely used as a building-stone. In this variety there is usually less oligoclase and hornblende, and the orthoclase and quartz crystals are of larger size.

The remarkable tendency to fall to pieces under the action of the weather, which, if we except the occurrence of microcline, is perhaps the most characteristic peculiarity of rapakivi, has given rise to a variety of attempted explanations. Some have inclined to the opinion that the phenomenon in question is due to the presence of iron. A strongly weathered rapakivi from Lappträsk, however, was found to contain 7·62 per cent. of iron, while an unweathered sample from Elima gave as much as 6·53 per cent.—a difference in amount hardly sufficient to explain the observed variations in behaviour towards the weather. Others again attribute the opposite effects observed in the two varieties to the different proportions of silica. Here are some analyses bearing upon the question :—

	Silica.
A non-weathered rapakivi from Strömfors	67·44
A similar rapakivi from Elima	69·17
Rapakivi from Korsmalm, near Lappträsk, much weathered	77·61

There seems, however, to be no reason why a high percentage of silica should conduce to weathering, and it does not always appear to be the case that the weathered specimens contain more silica than the unweathered. Probably Moberg is right in attributing the principal rôle in the matter to the oligoclase which weathers easily and occurs in greater amount in the weathered samples.

At a few places within the rapakivi territory it is pierced by dykes of a younger granite consisting mainly of orthoclase and quartz as at Norrby, near Lappträsk.

Rapakivi is everywhere very much jointed and the jointing takes place in certain regular directions.

This peculiar rock is, as is well known, confined exclusively to Finland, with the exception of the boulders which were transported thence to the North German Plains by the agency of ice during the Glacial Period, where they are to be met with very frequently and have been elaborately described by v. Ungern Sternberg (N. Jahrb. f. Min. 1882).

There is another rapakivi district in the West of Finland, in the neighbourhood, namely, of Nystad. Here the rock differs a good deal from the southern and more characteristic type described above. The structure there so common, according to which the orthoclase balls are surrounded by a sort of mantle of oligoclase, is here seldom observed. On the contrary, the orthoclase usually occurs in separate crystals of considerable dimensions, and the general matrix of the rock surrounds the balls or nodules of orthoclase without any intermediary concentric oligoclase layer.

Microscopically it differs also from the other variety in being destitute of microcline. It occasionally shows micro-pegmatitic structure; and its quartz is peculiar, being very idiomorphically developed and containing long needles (microliths) of a dark-coloured mineral which the American geologist Hawes declares to be rutile.

In its stratigraphical relationships the western rapakivi is very interesting, a great deal of evidence having been collected tending to show that it has both exercised an enormous pressure on the rocks through which it has been forced, and has itself in places been modified by this pressure, which may perhaps justify the assumption that it was in a very pasty condition when irrupted. The southern rapakivi on the contrary does not appear to have modified the surrounding rocks at all.

Great masses of granite, syenite, and elæolite-syenite occur throughout the country; but as they do not on the whole differ from similar rocks in other districts, I have not devoted any space to a description of them.

The various questions relating to the origin, characteristics and occurrence of pegmatites, I propose to reserve for future consideration.

NOTICES OF MEMOIRS.

THREE PAPERS ON GRAPTOLITES.

1. UEBER DAS ALTER DES SOGEN. GRAPTOLITHEN-GESTEINS MIT BESONDERER BERÜCHSICHTIGUNG DER IN DEMSELBEN ENTHALTENEN GRAPTOLITHEN. Von HERRN OTTO JAEKEL, in Berlin. Zeitschr. d. deutschen geolog. Gesellschaft, Jahrg. 1889, pp. 653–716, Taf. xxviii. xxix.
2. GOTLANDS GRAPTOLITER. Af GERHARD HOLM. Bihang till K. Svenska Vet.-Akad. Handlingar, Bd. 16, Afd. iv. No. 7 (1890), pp. 1–34, Taf. 1, 2.
3. UNDERSÖKNINGAR ÖFVER SILJANSOMRÅDETS GRAPTOLITER. Af Sv. LEONH. TÖRNQUIST. Lunds Univ. Årsskrift. Tom. xxvi. pp. 1–33, Taf. i. ii.

1. ON THE AGE OF THE SO-CALLED GRAPTOLITE STONE, WITH SPECIAL REFERENCE TO THE GRAPTOLITES CONTAINED THEREIN. By OTTO JAEKEL.
2. THE GRAPTOLITES OF THE ISLAND OF GOTLAND. By GERHARD HOLM.
3. AN EXAMINATON OF THE GRAPTOLITES OF THE DISTRICT OF SILJAN, DALARNE, SWEDEN. By SV. LEONH. TÖRNQUIST.

SCATTERED through the Drift of Northern Germany there are numerous boulders of calcareous rock containing, with various other fossils, several species of Graptolites, and for this reason they were styled "Graptolithen-gestein" by Ferd. Roemer. The parent-rock of these boulders, situated somewhere in the Silurian basin of the Baltic, has not yet been discovered, and different opinions have been expressed as to the particular divisions of the Silurian to which the boulders belong. By the majority of German geologists they have been referred to the highest series of the Silurian; the Swedish geologists on the other hand place them about the middle of the Upper Silurian series. With the view of elucidating the question, Dr. Jaekel has examined the Silurian outcrops in the West of England, and he finds that there is a very close correspondence both in the petrological characters and the fossils of these boulders with the beds of Wenlock Shale age exposed at Burrington, near Ludlow, and therefore he maintains that they really are of the age of the Wenlock Shale.

In the present paper the characters and the geological distribution of the fossils in the boulders are treated of, but the author more particularly refers to the Graptolites, and brings forward some new structural features which in his opinion will considerably modify their present classification. Thus in the genus *Monograptus*, two groups are proposed, based chiefly on the different position of the thecal aperture and its appendages. In the first of these, *Pristiograptus*, the aperture is free, and occupies the entire upper end of the theca, and the only appendages are spines on the lower margin of the aperture, and these are not always developed. In the second group, *Pomatograptus*, the outer portion of the theca is contracted, the aperture is small and situated beneath an extended roof-like process which forms the upper end of the theca. Hitherto the thecal aperture in these Graptolites has been supposed to be at the extreme end of this arched process, but the well-preserved examples figured by Dr. Jaekel show that this view is erroneous.

The author further maintains that Graptolites were not free-swimming organisms, but probably lived at the bottom of deep seas lightly anchored in the mud. He also considers that the simple forms of *Monograptus* are not complete, but only branches of colonial stocks; but, as pointed out by Dr. Holm, he seems to have overlooked the fact of the presence of the sicula, which is never wanting at the proximal end of the organism, and thus conclusively shows the primary commencement of the growth of the polypary. A description of the structure of *Retiolites* is likewise given, but in this no account is taken of the earlier works of Törnquist and Tullberg.

In the second paper above mentioned, Dr. G. Holm has revised the list of Graptolites occurring in the Silurian strata of the Isle of Gotland, and enumerates the following nine species and varieties; *Dictyonema cervicorne*, n. sp., *D. abnorme*, n. sp., *Monograptus priodon*, Bronn, *D. priodon*, var. *Flemingii*, Salt., *M. subconicus*, Törnq., *M. dubius*, Suess, *M.* sp., *Retiolites Geinitzianus*, Barr., and *R. nassa*, n.sp. A list is given of the names and distribution of the known species of *Dictyonema*, and a very careful description of a new species, *D. cervicorne*, based on specimens obtained free from matrix. In these the upper portion of the theca is extended into a long, spined process bifurcated at the extremity; and connected laterally with each theca there is a cup-like or nest-shaped structure, possibly a gonangium. Dr. Holm further describes and figures some remarkably well-preserved examples of *Retiolites* and *Stomatograptus*, in which the structural details are clearly shown.

In the third paper, Professor Törnquist describes 22 species of Graptolites occurring in the Ordovician and Silurian strata of the district of Siljan; of these the following are regarded as new, *Clonograptus robustus, Tetragraptus curvatus, Didymograptus gracilis, D. decens, Climacograptus internexus*, and *Diplograptus bellulus*. Many of the species in the area referred to are likewise common to the Coniston Flags and to the Quebec Group of Canada.

REVIEWS.

L'ARCHÉEN ET LE CAMBRIEN DANS LE NORD DU MASSIF BRETON ET LEURS ÉQUIVALENTS DANS LE PAYS DE GALLES. Par A. BIGOT, Docteur-ès-Sciences. (Cherbourg, 1890.)

DOCTOR BIGOT is a young French geologist who is rapidly winning his spurs. Having done excellent work amongst the older rocks of Northern France, he came over to Great Britain, and compared the systems with which he was familiar with some of the basal rock-groups of Wales and Shropshire. The results of this comparison are given in the work before us, and will be found to be in substantial agreement with the views maintained by those who in this country have paid the fullest attention to the Archæan and Cambrian rocks.

In the first part of his work Dr. Bigot describes the phyllads and purple conglomerates in the district of Saint-Lô and in the west of Calvados. From the typical area, he passes to the northern extension of these formations, as studied in the district round Cherbourg. He then takes up the same rock-groups south of Saint-Lô, and describes their occurrence in the south of Calvados, at Granville, and in the island of Jersey, which lies about 30 miles to the north-west of Granville. In Chapter IV. the author discusses the relation between the Phyllads and the older Palæozoic groups. Chapter V. gives an account of the eruptive rocks of Normandy and the Channel Isles; and Chapter VI. concludes the first part with a description of the general stratigraphy of the Breton *massif*. In the succeeding chapters the author discusses the correlations of the older rocks of north-western France with their equivalents in Pembrokeshire, North Wales, and Shropshire; and winds up with an excellent summary of his conclusions. Then follows a valuable bibliographic index, the authors being classed under the respective heads of "The Breton *massif*," and "Wales" (including Shropshire).

The schistose and slaty rocks named after the town of Saint-Lô, and usually referred to by French geologists as "schistes" or "phyllades," have been described by a long series of writers. Dufrénoy in 1838 identified them with the Cambrian of Great Britain, a very natural opinion at a time when the Longmynd series was accepted as typical Cambrian, and when the existence of slaty rocks below the Cambrian was not recognized in Europe.

Dufrénoy's identification was accepted by Dalimier, Bonissent, De Lapparent, and finally by Barrois, though it should be remarked that the last-named writer has been wont to quote Dufrénoy's opinion without positively endorsing it. Professor Hébert, however, adopting a Cambrian age for the "Conglomérats pourprés," and observing that these strata were unconformably superimposed upon the "Schistes de Saint-Lô," concluded that the latter were of Archæan age. In this opinion, the late Professor of Geology at the Sorbonne has been followed by his pupil, Dr. Bigot.

The evidence given in the volume before us would seem to be decisive of the true relation of the Saint-Lô Series to the purple conglomerates. The author confirms the existence of the stratigraphical discordance alleged by Hébert, and he affirms that the newer series contains pebbles of the sandstone which is intercalated amongst the Phyllads. The unconformity would therefore seem to be very marked.

The researches of Dr. Ch. Barrois and Dr. Bigot have brought to light additional resemblances between the rocks of Saint-Lô and the younger Archæans of Britain. According to the former writer, the Saint-Lô Series sometimes presents a volcanic facies. In the north of Brittany, acid rocks, such as "quartz-porphyries and petrosilex," are said by him to be interstratified with the Phyllads, and to furnish rounded fragments to the Conglomerates of Montfort, the equivalents of the "Conglomérats pourprés." Dr. Bigot records similar facts. He states that, at La Hogue and in the island of Alderney, the "purple conglomerates" contain pebbles of "petrosiliceous porphyries," evidently derived from an older formation.

According to Dr. Bigot, the district of La Hogue furnishes still more emphatic proof of the gap between the Phyllads and the purple conglomerate. A quarry displays a section of the Phyllads, penetrated by numerous veins of "granulite," and surmounted by the purple series. The veins are described as modifying the Phyllads, but producing no effect upon the purple beds; and it is inferred by Dr. Bigot that the older group was invaded and metamorphosed by the granite previous to the deposition of the purple conglomerates.

We are gradually learning that the resemblances between the newer Archæan rocks in Northern France and Western Britain are very close indeed. In the British area, the predominating types of rock in the Pebidian (or Uriconian) are acidic volcanic eruptives, hypometamorphic schists, grits more or less altered, and comparatively unaltered slates; and these are precisely the lithological characters most conspicuous in the Phyllads of Saint-Lô. The present writer accompanied Dr. Barrois and Dr. Bigot in the year 1888 to Caer Caradoc. Both of these geologists were struck with the lithological similarities between our Uriconian and the volcanic rocks associated with the Phyllads, and they have recorded their impressions in subsequent publications.

But the parallelism between the older rock-groups of the French and British areas has been shown to extend yet further. Dalimier, in 1861, and Bonissent, in 1870, recorded the occurrence of conglomerates intercalated in the Phyllads. Barrois, in 1884, gave a list of the contained pebbles, amongst which was a "granite identical with that of Chausey." Hébert, subsequently (1886) described this conglomerate, also identifying the Chausey granite amongst the pebbles, and he concluded that the conglomerate proved the existence of granites "older than the Archæan," the term "Archæan" by this writer being limited to the group called by us "Pebidian" or "Uriconian." Bigot supports Hébert's contention, and carefully distinguishes "the conglomerates of Granville, with pebbles of granite, intercalated in the vertical Phyllads" from "the purple conglomerates, almost horizontal, forming the base of a series which the *Grès Armoricain* conformably overlies," that is to say, he makes the former conglomerate Archæan, and the latter Cambrian.

The conglomerate of Granville strongly suggests the Archæan conglomerate, which, at Charlton Hill near the Wrekin, contains pebbles of a granite which is undistinguishable from a granite exposed in the Wrekin and at Malvern: and, if Hébert and Bigot are right in their reading of the Granville section, a granite of Pre-Uriconian age is proved in both the British and French areas.

Whether the Phyllads of Saint-Lô represent only the Pebidian (Uriconian) of Britain, or also include the equivalent of the Longmyndian, is at present an unsettled question. A small collection of typical specimens from the Phyllads, sent some years ago by Prof. Hébert to the present writer, would be considered thoroughly typical of our Pebidian, and not at all like our Longmyndian.

The rocks which unconformably overlie the Phyllads are considered by Dr. Bigot to represent the several horizons of our British Cambrian. In the following table he indicates the parallelism which he believes to subsist between the members of the older systems in the two areas.

Wales.	Normandie.
Arenig.	Grès armoricain.
—	—
Olenidian.	Grès feldspathiques.
Solva and Menevian.	Schistes verts et grès verts.
Caerfai.	Schistes rouges et marbres.
Conglomerate.	Poudingues pourprés.
—	—
Pebidian.	Schistes de Saint-Lô.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Feb. 20, 1891.—Annual General Meeting.—Dr. A. Geikie, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1890. In the former the Council once more congratulated the Fellows upon the continued prosperity of the Society, as evinced by its increasing number and by the satisfactory condition of its finances.

The number of Fellows elected during the year was 76, of whom 56 qualified before the end of the year, together with 16 previously elected Fellows, and these, with one Fellow readmitted, made a total accession of 73 Fellows during 1890. As, however, from this number a deduction of 43 was made for losses by death, resignation, and removal, and for new Fellows compounding, the actual increase in the number of Contributing Fellows was 30. The total number of Fellows, Foreign Members, and Foreign Correspondents at the close of the year 1890 was 1405.

The Balance-sheet for the year 1890 showed receipts to the amount of £3034 8*s*. 1*d*., and an expenditure of £2429 16*s*. 2*d*. Further, a sum of £420 10*s*. was expended in the purchase of stock, and the balance in favour of the Society at December 31, 1890, amounted to £433 17*s*. 6*d*.

The Council's Report also referred to the publication of the late Mr. Ormerod's Third Supplement to his Index to the Publications of the Society, to the editing of Nos. 183 and 184 of the Journal by Prof. T. Rupert Jones, to the deaths of the late Foreign Secretary and the late Assistant-Secretary, and in conclusion enumerated the awards of the various Medals and Proceeds of Donation-Funds in the gift of the Society.

The Report of the Library and Museum Committee included a list of the additions made during the past year to the Society's Library, and announced the completion of the glazing of the Inner Museum.

In presenting the Wollaston Medal to Prof. J. W. Judd, F.R.S., the President addressed him as follows:—

Professor Judd,—The Council have awarded to you the Wollaston Medal in recognition of the important services rendered by you to Geological science, especially in the department of Petrography. In recalling for a moment the value and extent of these services, I am reminded that, after showing your powers by an excellent paper on the strata of the Lincolnshire Wolds, you began your geological career in the Geological Survey under Murchison, and that you had thus a favourable opportunity of acquiring that practical acquaintance with the details of geological structure which can in no way be so thoroughly mastered as by actual patient mapping. Your volume on the "Geology of Rutland" proved how well you had profited by the advantages which your official duties afforded you. From the Jurassic rocks of England, which you had studied in minute detail, you were led to undertake the investigation of those of Scotland, which you succeeded in reducing to order, bringing them into closer relationship with their equivalents in the southern part of the United Kingdom.

It was in the course of those northern expeditions that you were drawn from the field of stratigraphy into the study of volcanic rocks, to which you have since devoted so large a part of your time and thought, and in the study of which you have journeyed far and wide in this country, and have extended your travels to the islands of the Mediterranean. The problems presented by these rocks in the field led you to seek the aid of the microscope, and to enter upon a course of distinguished petrographical research. I trust that the award of this Medal will be received by you as a mark of the estimation in which your work is held by the Society in whose Quarterly Journal most of it has been published.

Prof. Judd, in reply, said:—Mr. President,—It is a source of legitimate gratification to the student of science, when a favourable judgment on his efforts is pronounced by his contemporaries and fellow-workers. In receiving this highly-prized mark of your approval, I would fain forget for one moment, if that were possible, how far the work—of which you have spoken in such graceful terms—falls in amount below my hopeful anticipations of the past, how it fails to reach the standard of excellence of my cherished ideals. Any value which that work may be found to possess is undoubtedly due, in great part, to the fostering care of the Society which to-day so generously crowns my labours To the Geological Society, in its corporate capacity, I am indebted for the reception and publication of the results of my studies; to individuals composing that Society I owe more than I can ever express, for kind sympathy, warm encouragement, and friendly aid; and to both Council and Members I shall always be deeply grateful alike for helpful suggestion and discriminating criticism.

In handing the Murchison Medal awarded to Professor W. C. Brögger, of Christiania, to J. J. H. Teall, Esq., M.A., F.R.S., for transmission to the recipient, the President spoke as follows:—

Mr. Teall,—The Council has awarded the Murchison Medal to Professor W. C. Brögger, of Christiania, and in asking you to transmit it to him I will request you also to convey to him an expression of the high estimation in which we hold his researches among the older rocks of Scandinavia. He is remarkable among the geologists of Europe for the great range of his acquirements. If we were to read only his descriptions of the Silurian fauna of Southern Norway we should, doubtless, believe him to be essentially a palæontologist. If we looked over his maps and sections of the Christiania district, we should think of him rather as an admirable stratigrapher and cartographer. If, again, we began with his account of the eruptive rocks and their zone of contact-metamorphism, we should conclude that his chief studies must have lain in microscopic and chemical petrography, of which he is so accomplished a master. Or, lastly, if we knew him only by such essays as his late paper on garnets, we should regard him as preeminently a mineralogist, gifted with rare originality. He has swept a full chord on the geological lyre, and every note sounds rich and true.

It gives me personally an especial pleasure to be the intermediary in conveying the award of the Council, for I have had the advantage of being conducted by Professor Brögger over some of his classic ground around Christiania, and I know from my own experience how accurate and exhaustive is the work: how courteous, genial, and helpful the man. He will, I trust, receive this Medal, bearing the likeness and the name of one of the great masters of British Geology, who was also a pioneer in the geology of Norway, as a pledge of our esteem and sympathy with him in the great work he has already accomplished, and in the long and brilliant career which we hope is still in store for him.

Mr. Teall, in reply, read the following communication received by him from Professor Brögger:—"I beg to express my hearty gratitude for the great and completely unexpected honour conferred upon me by the Council of the Geological Society in the award of the Murchison Medal.

"The Founder of this Medal, almost half a century ago, classified the Silurian rocks of the Christiania district, and pointed out their relations to the corresponding strata of Great Britain; so that, if the subsequent investigations of Norwegian geologists have furnished results of interest to the students of British Geology, this is only a slight repayment of an old debt.

"In ancient times the mountain-ranges of northern Great Britain and Norway were probably connected and, in the Quaternary period, the Scandinavian ice-sheet stretched across to England and deposited boulders of Norwegian rocks, some of which were derived from the Christiania district. Now, in recent times science has rebuilt the bridges which formerly connected the two countries, inhabited by closely related peoples of the Germanic race.

"It will be an object of special interest to me to contribute, as far as I am able, to the reconstruction of bonds of union between Great Britain and Norway, in grateful remembrance of the benefits which Norwegian geologists in general, and I myself in particular, have derived from the celebrated Geological Society of London.

"Allow me, in conclusion, to express the great satisfaction I feel at receiving this honour during the Presidency of so eminent a geologist as Dr. Archibald Geikie, who is personally acquainted with the geology of Norway."

The President then presented the Lyell Medal to Professor T. McKenny Hughes, F.R.S., addressing him as follows:—

Professor Hughes,—The Lyell Medal has this year been adjudged by the Council to you in appreciation of the value of your investigations in various departments of Geology, especially among the older rocks. Your researches in Caernarvonshire and Anglesey formed the starting-point of those later inquiries which have done so much to clear up the earlier chapters of the geological history of Wales. You have not confined yourself, however, to the rocks of any one system or period, but have ranged freely from the Archæan gneiss to raised beach, hovering for a moment here and resting a little there, generally critical, almost always suggestive, and with that happy faculty of enthusiasm which, reacting on younger minds, "allures to older worlds, and leads the way."

As I place this Medal in your hands, I cannot but recall the days of our early friendship, now faded so far into the dim past of life, when, as colleagues in the Geological Survey, we used to attend the meetings of this Society in Somerset House, taking seats on a back row and gazing down upon the magnates of the science seated beneath. Little did either of us dream that the whirligig of time would eventually place us where we find ourselves to-day. It is thus no small gratification to me to be called upon to present to you this Medal, which will not only serve to mark the Society's appreciation of your work, but which will connect you by another link with the memory of our friend and master, Lyell.

Prof. Hughes, in reply, said:—Mr. President,—I feel that I have, as the senior, been selected to receive this high recognition of the work being carried on by the Cambridge School of Geology. I have not myself been able to offer much to the Society of late, save occasional criticism, but my colleagues, Mr. Marr and Mr. Harker, Fellows of the Society, whose opinions are regarded each year with increasing respect, the one your Secretary, the other on your Council, have from time to time contributed valuable papers, while my other colleague, Mr. Roberts, has also laid before the Society the results of important original observations made by him. The Society knows that it is chiefly to the lecture-room, the museum, and the field-classes that it must look for men to carry on its work in the future. But I must acknowledge in this respect also that the heaviest work has fallen upon my colleagues. They know, however, that in the administration of the Department, and directly and indirectly in promoting the cause of Science, I help as far as I can. We all work well together, and I feel that they will rejoice with me now, will help to carry back the Lyell Medal in triumph to Cambridge, and will join with me in offering to the Society our warmest thanks for the honour that has been done us. We shall regard it as a stimulus to follow in the steps of the great teacher whose name is commemorated on the Medal, and try always to distinguish clearly between what is proved, what is disproved, and what remains, however plausible, "not proven."

I am glad that it has fallen to my lot to receive this honour from the hands of an old and valued friend, upon whom has fallen the mantle of Lyell, a mantle in which the warp of science and the weft of literature are so deftly interwoven.

The President then handed the Bigsby Medal, awarded to Dr. G. M. Dawson, F.G.S., of Ottawa, to Dr. Hicks, F.R.S., for transmission to the recipient, and addressed him as follows:—

Dr. Hicks,—In asking you to transmit the Bigsby Medal to Dr. George M. Dawson, I request you to convey to him at the same time an assurance of how fully the Council appreciates the value of his researches into the geological structure of Canada, and how cordially we hope that he may live long to prosecute the explorations which have shed so much lustre on the Geological Survey of his native country.

Dr. Hicks, in reply, read the following communication, received by him from Dr. Dawson:—"Mr. President,—I have to express my high appreciation of the honour which you and the Council of the Geological Society have conferred upon me in the award of the Bigsby Medal.

"I regret that my official duties at the present time render it impossible for me to be present in person at the Anniversary Meeting to assure the Society of the high esteem in which I hold this mark of recognition.

"My field of geological work has laid chiefly in the further Western, and as yet imperfectly known, portions of the Dominion of Canada, and much of the work itself has been of an exploratory character, and only occasionally, and then to a limited extent, precise or finished. Work of this class, though necessary in the first instance, and possessed of the special interest attaching to any virgin field, must suffer by comparison with that obtained in the investigation of smaller areas, and carried on under more favourable conditions. It is thus all the more gratifying and encouraging to me that such results as I have been able to obtain should be deemed worthy of the recognition of the Society.

"I may be pardoned for alluding to the fact that some of the earliest work in Canadian Geology is due to the personal efforts of the distinguished Founder of this Medal, in whose very footsteps it has at times been my privilege to follow. This, with the pleasant remembrance of advantages derived in former years from personal intercourse wlth Dr. Bigsby, and kindly advice received from him, tend to enhance, if possible, the sense of gratification felt by me in learning that my name has been added to the roll of those considered worthy to receive the Bigsby Medal."

In presenting the Balance of the Wollaston Fund to Richard Lydekker, Esq., B.A., F.G.S., the President said:—

Mr. Lydekker,—The Council has awarded to you the Proceeds of the Wollaston Donation Fund in recognition of the value of your numerous contributions to Vertebrate Palæontology. We trust that you will continue these investigations and that, whether they appear in the publications of this Society or elsewhere, the results, like those which have preceded them, may tend to the steady advancement of our favourite science.

Mr. Lydekker, in reply, said:—Mr. President,—The particular branch of Palæontology to which my own studies have been more especially directed is one which, from its nature, is so beset with difficulties that it is very apt to lead to misgivings as to whether any real good results from its pursuit. The assurance conveyed by the honour that the Council of the Society has conferred upon me, that such work as I have been able to do is not unappreciated, is therefore very gratifying.

Although circumstances have rendered it almost imperative that I should devote my time to literary work rather than to original scientific research, yet I still hope to do something in the latter field.

Please accept, Sir, on behalf of the Council, my thanks for the mark of distinction that they have bestowed upon me.

In handing the Balance of the Murchison Geological Fund (awarded to the Rev. Richard Baron, F.L.S., F.G.S., of Antananarivo) to Wm. Topley, Esq., F.R.S., for transmission to the recipient, the President said:—

Mr. Topley,—I have to request you to transmit to the Rev. R. Baron the Balance of the Proceeds of the Murchison Geological Fund, in testimony of the interest taken by the Council in the geological work which, amid so many discouragements, he is carrying on in Madagascar. We desire him to accept this Award as a mark of our hearty sympathy and of our wish to aid him in his researches.

Mr. Topley, in reply, said:—Mr. President,—On behalf of Mr. Baron, who is now in Madagascar, I beg to thank the Council and yourself for the honour conferred upon him in the award of the Murchison Fund. As a Missionary in an area as yet but little known, Mr. Baron has exceptional opportunities for original research, and that he has not neglected those opportunities is evident from his papers already read to this Society and to the Linnean Society. The Award now made will, I am sure, be an incentive to further work in a most promising field of research.

The President then handed one half of the Balance of the Lyell Geological Fund, awarded to Dr. C. J. Forsyth-Major, of Florence, to Dr. H. Woodward, F.R.S., for transmission to the recipient, and addressed him as follows:—

Dr. Woodward,—In requesting you to transmit to Dr. Forsyth-Major one moiety of the Balance of the Lyell Geological Fund, I wish to express the Council's appreciation of his researches and its hope that he will continue them. He has done much to increase our knowledge of the Pliocene Mammalia of the Val d'Arno, and he has recently extended his explorations among the younger Tertiary deposits of the Eastern Mediterranean.

Dr. Woodward, in reply, said:—Mr. President,—On behalf of Dr. C. J. Forsyth-Major, I have to acknowledge the honour conferred upon him by the Council of this

Society in awarding him a moiety of the Lyell Fund. The work to which Dr. Forsyth-Major has devoted his life so entirely accords with the researches and labours of Sir Charles Lyell that I cannot doubt the appropriateness of this Award.

Dr. Forsyth-Major has devoted many years to the elucidation of the Pleistocene and Pliocene mammalian faunas of the Val d'Arno and Northern Italy, and his numerous memoirs attest the value and accuracy of his work. Lately he has devoted two years to the exploration of the Pliocene fauna of the Island of Samos, and has obtained thence two very important collections (at present only partially examined)—one now in the Geneva Museum, the other in the British Museum (Natural History), Cromwell Road. Among these are a large number of forms specifically identical with the mammals from the equivalent deposits of Pikermi in Attica, Baltavar in Hungary, and Maragha in Persia; and also several new types of much interest as showing a former wider distribution for existing forms.

It is Dr. Forsyth-Major's hope to spend the early summer months in London, to complete his descriptions of these fossil remains, which your Award will doubtless assist him in doing.

He writes as follows:—"Would you kindly transmit to the President and Council of the Geological Society my grateful acknowledgments of the honour conferred upon me, which I value so much the more as coming from a scientific body of my own country, to which, owing to the fact that my family resides abroad, I have become nearly a stranger.

"If I rightly understand the intention of the Council, this Award is given less as a mark of their approval of what I have already done than as an incentive to future labours.

"In my palæontological work I have striven to follow the example of one of the masters of our science, the late Dr. Hugh Falconer, devoting myself more to the collecting of facts and observations than to their speedy publication. This reserve seems to be imposed upon us even more in our day than in that of Dr. Falconer's."

In presenting the other half of the Balance of the Lyell Geological Fund to G. W. Lamplugh, Esq., F.G.S., the President addressed him as follows:—

Mr. Lamplugh,—The Council, in awarding to you one-half of the Proceeds of the Lyell Geological Fund, desires to assure you of the estimation in which it holds your work, and of the pleasure it will derive from their further prosecution. Your researches among the Glacial deposits of Yorkshire have been followed with much interest, and we have rejoiced in the enthusiasm which not only carried you through these labours at home, but which impelled you to seek the solution of some of your difficulties by journeying to the far distant shores of British Columbia. Your investigation of the Speeton Clay affords a striking example of how our knowledge may be corrected and extended by the patient labours of an observer resident on the spot which he has to examine. I hope you will accept this Award with the best wishes of the Council and of the Society.

Mr. Lamplugh, in reply, said:—Mr. President,—That I should have been selected by the Council to receive this Award affords me the greatest encouragement, since it comes to me as a token that my geological work, in spite of its narrow and local character, has after all a certain value.

It is scarcely possible that any one who has any sympathy whatever with Nature should spend much time on the Yorkshire coast without becoming more or less of a geologist, and for my own part I drifted almost unconsciously into these studies in my boyhood, and have ever since found therein my happiest and healthiest recreation. My pleasure in them is now redoubled by this proof that the time so happily spent has also been spent usefully.

I thank you, and hope that, as a coastguard in the service of science, I may still occasionally be able to send to headquarters reports which may contain some items of interest.

The President proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Fellows, Foreign Members, and Foreign Correspondents deceased since the last Annual Meeting, including the late Foreign Secretary Sir Warington W. Smyth, the late Assistant-Secretary Mr. W. S. Dallas, M. Edmond Hébert and M. Alphonse Favre (Foreign Members, both elected in 1874), Mr. Wm. Davies, Mr. Robert Wm. Mylne, Mr. Samuel Beckles, Dr. H. B. Brady, Mr. Samuel Adamson, and Prof. Antonio Stoppani (Foreign Correspondent, elected in 1889).

He then dealt with the history of volcanic action in Britain during the earlier ages of geological time. He proposed to confine the term "Archæan" to the most ancient gneisses and their accompaniments, and showed that these rocks, so far as we know them in this country, are essentially of eruptive origin, though no trace has yet been found of the original discharge of any portion of them at the surface. Passing to the younger crystalline schists, which he classes under the term "Dalradian," he pointed to the evidence of included volcanic products in them throughout the Central Highlands of Scotland and the North of Ireland. The Uriconian series of Dr. Callaway he regarded as a volcanic group, probably much older than the recognized fossiliferous Cambrian rocks of this country. The Cambrian system he showed to be eminently marked by contemporaneous volcanic materials, and he discussed at some length the so-called pre-Cambrian rocks of North Wales. He reviewed the successive phases of eruptivity during the Arenig and Bala periods, and described the extraordinary group of volcanoes in Northern Anglesey during the latter time. The volcanoes of the Lake District were next treated of, and reference was made of the recent discovery by the Geological Survey that an important volcanic group underlies most of the visible Lower-Silurian rocks in the South of Scotland. The last portion of the Address was devoted to an account of the volcanoes of Silurian time in Ireland, and it was shown that during the Bala period a chain of submarine volcanic vents existed along the east of Ireland from County Down to beyond the shores of Waterford; while in Upper-Silurian time there were at least two active centres of eruption in the extreme west of Kerry and in Mayo.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*Council*: Prof. J. F. Blake, M.A.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; James Carter, Esq.; James W. Davis, Esq., F.L.S., F.S.A.; John Evans, D.C.L., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; C. Le Neve Foster, D.Sc., B.A.; A. Geikie, LL.D., F.R.S.; A. Harker, Esq., M.A.; J. C. Hawkshaw, Esq., M.A.; H. Hicks, M.D., F.R.S.; G. J. Hinde, Ph.D.; W. H. Hudleston, Esq., M.A., F.R.S.; Prof. T. McKenny Hughes, M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; J. E. Marr, Esq., M.A.; H. W. Monckton, Esq.; F. W. Rudler, Esq.; J. J. H. Teall, Esq., M.A., F.R.S.; W. Topley, Esq., F.R.S; Prof. T. Wiltshire, M.A., F.L.S.; H. Woodward, LL.D., F.R.S.

OFFICERS.—*President*: A. Geikie, LL.D., F.R.S. *Vice-Presidents*: W. T. Blanford, LL.D., F.R.S.; Professor T. G. Bonney, D.Sc., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; W. H. Hudleston, Esq., M.A., F.R.S. *Secretaries*: H. Hicks, M.D., F.R.S.; J. E. Marr, Esq., M.A. *Foreign Secretary*: J. W. Hulke, Esq., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S.

CORRESPONDENCE.

THE SAIGA ANTELOPE IN BRITAIN.

SIR,—In the February Number of the GEOLOGICAL MAGAZINE, p. 94, is a notice of the discovery of the horns of the Saiga Antelope in the Thames Gravels at Twickenham. An earlier discovery was, however, made some years ago of this northern animal by the late Mr. R. W. Mylne. The specimens, which consisted of two horn-cores, were shown by him to me, and I submitted them to Mr. G. Busk, who pronounced them to belong to the Saiga Antelope. Unfortunately Mr. Mylne could not say where they came from. He thought from the neighbourhood of Bedford, and said he would make further inquiries. Those inquiries must have failed to elicit anything further, waiting for which has been the reason of this long delay in making the announcement—a reason now removed by the discovery of this new locality and the certainty of British origin.

JOSEPH PRESTWICH.

OBITUARY.

THE PALÆONTOLOGICAL WORK OF THE LATE WILLIAM DAVIES, F.G.S.

IN Mr. William Davies, whose death we regretted to have to record last month,[1] another link between the present school and the pioneers in British Vertebrate Palæontology has been severed. His official connexion with the British Museum placed him in the midst of a circle which included Mantell, Owen, Falconer, Agassiz, Egerton, Hugh Miller, and others, at a time when they were actively engaged in prosecuting those researches which form the basis of subsequent investigation. His mind, already imbued with the scientific method and deeply interested in the problems of Natural History, was soon permanently influenced by such associations; and the result was a keenness of perception in the determination of fragmentary remains of Vertebrata that has rarely been surpassed. In this manner Mr. Davies not only became a trusted ally and adviser of the old school of investigators, but also proved himself one of the best of helpers to the later generations that have succeeded. There are few workers of the last three decades in Vertebrate Palæontology who have not been indebted to Mr. Davies at some time for advice in difficult problems, and there are many who owe much to his kindly manner and the influence of his enthusiasm.

In his influence upon others, indeed, and in the remarkable skill with which he was able to preserve and mount even the most unpromising fossils, lay Mr. Davies' chief power as a factor in the progress of Palæontology. Wanting the literary training which it was difficult for any but the rich to obtain during his early years, he usually avoided the laborious task of writing an account of his work in a suitable form for publication. His discoveries and conclusions were always at the service of those who could make best use of them; and he was never in a happier mood than when showing the latest novelties in the British Museum to those who could appreciate them and publish the new facts in a form that would tend to the advancement of knowledge. From 1865 onwards, however, Mr. Davies was an occasional contributor to the GEOLOGICAL MAGAZINE; and in 1886 he added a short description of the Vertebrate fossils to Dr. Henry Hicks' paper on the caves of the Vale of Clwyd in the Quarterly Journal of the Geological Society. Apart from incidental observations and letters, these contributions may be enumerated as follows:—

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[1] See GEOLOGICAL MAGAZINE, March, 1891, p. 144.

1865. On the Preservation of Fossil Mammalian Remains found in Tertiary Deposits, GEOL. MAG. Vol. II. pp. 239, 240.

1871. Alphabetical Catalogue of Type Specimens of Fossil Fishes in the British Museum, *ibid.* Vol. VIII. pp. 208–216, 334.

1872. On the Rostral Prolongations of *Squaloraia polyspondyla*, Ag., *ibid.* Vol. IX. pp. 145–150, Pl. IV.

1874. (With H. Woodward.) Notes on the Pleistocene Deposits yielding Mammalian Remains in the Vicinity of Ilford, Essex, *ibid.* Dec. II. Vol. I. pp. 390–398.

1876. On the Exhumation and Development of a large Reptile (*Omosaurus armatus*, Owen), from the Kimmeridge Clay, Swindon, *ibid.* Dec. II. Vol. III. pp. 193–197, Pls. VII. VIII.

1878. On a Collection of Pleistocene Mammals Dredged off the Eastern Coast, *ibid.* Dec. II. Vol. V. pp. 97–100.

1878. On the Nomenclature of *Saurocephalus lanciformis* of the British Cretaceous Deposits; with Description of a New Species (*S. Woodwardii*), *ibid.* Dec. II. Vol. V. pp. 254–261, Pl. VIII.

1879. On some Fish Exuviæ from the Chalk, generally referred to *Dercetis elongatus*, Ag.; and on a New Species of Fossil Annelide, *Terebella Lewesiensis*, *ibid.* Dec. II. Vol. VI. pp. 145–148.

1879. On some Recently Discovered Teeth of *Ovibos moschatus* from Crayford, Kent, *ibid.* Dec. II. Vol. VI. pp. 246–248.

1880. On some Fossil Bird-Remains from the Siwalik Hills in the British Museum, *ibid.* Dec. II. Vol. VII. pp. 18–27, Pl. II.

1880. On some Bones of the Lynx from Teesdale, obtained by Mr. James Backhouse, of York, *ibid.* Dec. II. Vol. VII. pp. 346–349, Pls. XI. XII.

1884. Note on Remains of the Emu from the Wellington Caves, New South Wales, *ibid.* Dec. III. Vol. I. p. 265.

1884. Note on some New Carnivores from the British Eocene Formations, *ibid.* Dec. III. Vol. I. pp. 433-438, Pl. XIV.

1886. Note on the Animal Remains from some Bone-Caves in North Wales (Ffynnon Beuno and Cae Gwyn), Quart. Journ. Geol. Soc. vol. xlii. pp. 17–19.

1887. On New Species of *Pholidophorus* from the Purbeck Beds of Dorsetshire, GEOL. MAG. Dec. III. Vol. IV. pp. 337–339, Pl. X.

Mr. Davies' long association with Sir Antonio Brady in recovering the remains of fossil Mammalia from the brick-fields near Ilford, resulted in 1874 in the publication of "A Catalogue of the Pleistocene Vertebrata in the Collection of Sir Antonio Brady," which is of great value on account of its well-known accuracy. This was the only separate publication he undertook as author, though by no means the only one in the preparation of which he played an important part. In Fossil Fishes, Prof. L. G. de Koninck acknowledges Mr. Davies' important aid when preparing the first part of the "Faune Calc. Carbonif. Belgique"; and the author of the first two volumes of the British Museum Catalogue of Fossil Fishes expresses his indebtedness to Mr. Davies, not only for much advice, but also for his revision of the whole of the proof-sheets. Notwithstanding his previous retirement from active service, Mr. Davies also undertook the revision of the proofs of the British Museum Catalogue of Fossil Reptiles. As Sir Richard Owen remarks, the discovery of the cranium of *Dasornis* was due to Mr. Davies, who recognized it among some fish-remains from the London Clay; and to the skilled manipulation of the same observer we are indebted for the well-displayed jaws of *Odontopteryx.* Prof. Leith Adams was in continual communication and consultation with Mr. Davies while preparing his Memoir on British Fossil Elephants, of the dentition of which our lamented friend had unrivalled knowledge; and the British Museum Catalogue of Fossil Mammalia owes much of its value as a record of the history of specimens to its careful revision by the same hand. Only a little more than a year ago, Mr. Davies entered with his usual enthusiasm upon the reading of the proofs of Messrs. Woodward and Sherborn's "Catalogue of British Fossil Vertebrata," to which he made important contributions; and several of his letters, containing information of much historical value in reference to literature and specimens, are now preserved in a bound volume in the Geological Library of the British Museum.

Apart from all literary work, however, Mr. William Davies leaves some enduring monuments in the British Museum. The great head of the Ilford Mammoth was rescued from destruction entirely by his skill in the disinterment of such remains; and the same remark applies to many of the unique gems in the Brady Collection. The bones of the huge *Omosaurus* from the Kimmeridge Clay of Swindon were extricated from a difficult matrix, or built up from apparently worthless fragments, in part by his own hand, in part under his direction. *Hyperodapedon*—one of the latest acquisitions—was worked out by the masons under the same supervision; and Mr. Davies played no unimportant part in superintending the extrication from the matrix of some of the finest examples of Siwalik Mammals and South African Reptiles. Palæontology has, indeed, lost a master-hand.

A. S. W.

MISCELLANEOUS.

THE INTERNATIONAL GEOLOGICAL CONGRESS,

WASHINGTON, 26TH AUGUST, 1891.

THE negociations respecting the proposed change in the date and locality of the next meeting of the International Geological Congress were at length brought to a conclusion by the American Organizing Committee. It has now been decided that the Congress shall be held in Washington during the week commencing Wednesday 26th August, 1891. Sub-committees have been formed to arrange for the scientific business, the long excursions, the local arrangements, and for the nomination of officers. A circular has been issued announcing the proposed arrangements, and cordially inviting all Geologists to take part in the labours of the Congress.

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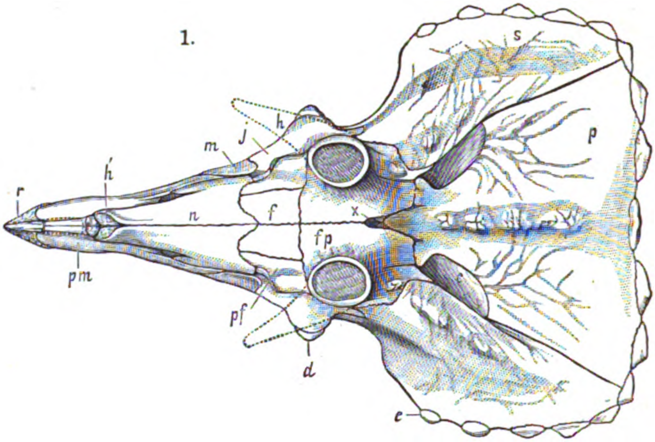

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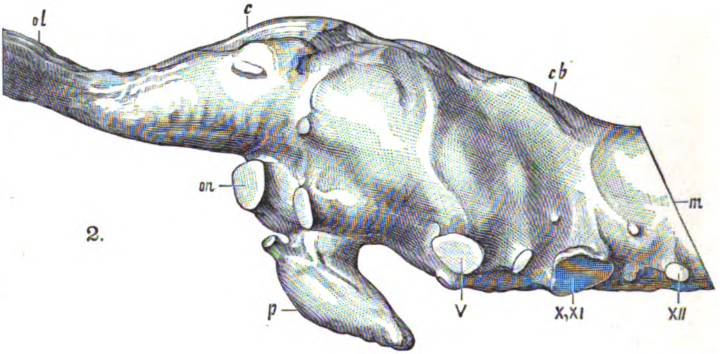

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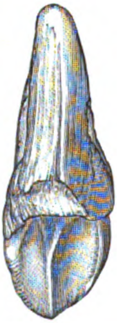

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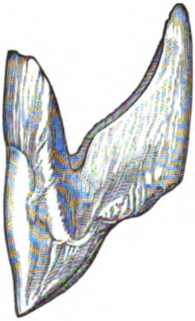

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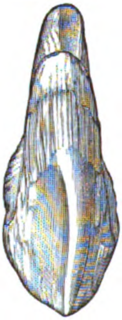

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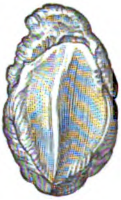

To illustrate Prof. O. C. MARSH's second paper on *Triceratops*, from the Upper Cretaceous of North America.

(For Part I. see GEOL. MAG. 1890, p. 1, Pl. I.)

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VIII.

No. V.—MAY, 1891.

ORIGINAL ARTICLES.

I.—THE GIGANTIC CERATOPSIDÆ, OR HORNED DINOSAURS, OF NORTH AMERICA.[1]

(PART II.)

By Prof. O. C. MARSH, Ph.D., LL.D., F.G.S., etc.

(PLATES IV.[2] AND V.)

TWO years ago at the Bath Meeting of the British Association, I had the honour to present a paper in which I compared the principal known Dinosaurs of Europe with those of America.[3] In this communication I referred to some peculiar reptilian remains from the Gosau formation of Austria, and compared them with certain Laramie fossils from America, about which I hoped soon to have more definite information. As an indication of the rapidity with which knowledge of ancient life is advancing, it may be interesting to know what has been learned in two years concerning this single group of the remarkable reptiles known as *Dinosauria*. This group I have termed the *Ceratopsidæ*, and I shall refer especially to the forms I have recently investigated, and hope to describe more fully later on, under the auspices of the United States Geological Survey.

The geological horizon of the *Ceratopsidæ* in America is a distinct one in the Upper Cretaceous, and has now been traced nearly eight hundred miles along the eastern flank of the Rocky Mountains. It is marked almost everywhere by remains of these reptiles; hence I have called the strata containing them the Ceratops beds. They are fresh-water or brackish deposits, which form a part of the so-called Laramie, but are below the uppermost beds referred to that group.

The fossils associated with the *Ceratopsidæ* are mainly Dinosaurs, representing two or three orders, and several families. Plesiosaurs, Crocodiles, and Turtles of Cretaceous types, and many smaller reptiles, have left their remains in the same deposits. Numerous small mammals, also of ancient types, a few birds, and many fishes, are likewise entombed in this formation. Invertebrate fossils and plants are not uncommon in the same horizon.

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[1] Read before Section C of the British Association for the Advancement of Science, at the Leeds Meeting, September 4, 1890. See also American Journal of Science (3), vol. xxxvi. p. 477, December, 1888; vol. xxxvii. p. 334, April, 1889; vol. xxxviii. p. 173, August, 1889, p. 501, December, 1889; and vol. xxxix. p. 81, January, 1890, p. 418, May, 1890.

[2] For Plate IV. see the April Number GEOL. MAG.

[3] Report of the British Association for the Advancement of Science for 1888, p. 660. London. 1889. Abstract, American Journal (3), vol. xxxvii. p. 323, April, 1889. See also GEOL. MAG. 1890, pp. 1–5, and Pl. I.

THE SKULL of one species was described and illustrated in the GEOLOGICAL MAGAZINE for 1890 (Dec. III. Vol. VII. Pl. I. pp. 1–5), to which it will be sufficient to refer the reader. But the following notes, *supplementary* thereto, form part of the paper which appeared in the "American Journal of Science" for February, 1891. Additional figures of the skull have since been prepared and are given in Plates[1] IV. and V.

In the figures of *Triceratops flabellatus* (see GEOL. MAG. 1890, Pl. I. Figs. 1, 2), it was pointed out that the rostral bone was free and was not secured (*op. cit.* p. 2), but, in another skull, represented in Pl. IV. Figs. 2, 3, 4, and 5, the rostral bone and nasal horn-core are in position, and firmly coössified with the adjoining elements.

The frontal bones are quite short, and early unite with each other and with the adjoining elements, especially those behind them. The frontal or central region of the skull is thus greatly strengthened to support the enormous horn-cores which tower above. These elevations rest mainly on the post-frontal bones, but the supra-orbitals and the post-orbitals are also absorbed to form a solid foundation for the horn-cores. These horn-cores are *hollow at the base* (see Pl. V. Fig. 1), and in general form, position, and external texture agree with the corresponding parts of the *Bovidæ*.

The post-frontal bones are very large, and meet each other on the median line. Posteriorly they join the squamosals and the parietals. At their union with the latter there is a median foramen (Pl. V. Fig. 1, *x*), which apparently corresponds to the so-called "parietal foramen."[2]

In old individuals it is nearly or quite closed. When open, it leads into a large sinus, extending above the brain-case into the cavities of the horn-cores. This foramen has not before been observed in Dinosaurs.

The palatine bones are much smaller than the pterygoids. They are vertical, curved plates, outside and in front of the pterygoids, and uniting firmly with the maxillaries. The vomers join the pterygoids in front, where they appear as thin bones, closely applied to each other.

The transverse bones give some support to the maxillaries, which are further strengthened by close union with the pterygoids. They meet the pterygoids behind, and the palatines in front.

THE BRAIN.—The brain of *Triceratops* appears to have been smaller in proportion to the entire skull than in any known Vertebrate.

The position of the brain in the skull does not correspond to the axis of the latter, the front being elevated at an angle of about thirty degrees (Plate V. Fig. 2).

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[1] Plate IV. appeared in the April Number, 1891; Plate V. is in the present Number.

[2] The name usually applied to this aperture is misleading, as in *Chameleo* and some other reptiles the foramen is not in or near the parietal bones. It may more properly be called the "pineal foramen."

The brain-case is well ossified in front, and in old animals there is a strong septum separating the olfactory lobes.

TEETH OF TRICERATOPS.—The teeth of *Triceratops* and its near allies are very remarkable in having two distinct roots. This is true of both the upper and lower series. These roots are placed transversely in the jaw, and there is a separate cavity, more or less distinct, for each of them. One of these teeth from the upper jaw, represented by figures of the natural size (Plate V. Figs. 3–6), are typical of the group.

The teeth form a single series only in each jaw. The upper and lower teeth are similar, but the grinding face is reversed, being on the inner side of the upper series, and on the outer side of the lower series. The sculptured surface in each series is on the opposite side from that in use.

The teeth are not displaced vertically by their successors, but from the side. The crown of the young tooth, also with two strong roots, cuts its way between the alveolar margin and the adjacent root of the old tooth, sometimes advancing between the two roots, as might be expected.

The teeth in this family are entirely confined to the maxillary and dentary bones. The rostral bone, the premaxillaries, and the pre-dentary, are entirely edentulous.

CERVICAL AND DORSAL VERTEBRÆ.—The atlas and axis of *Triceratops* are coössified with each other, and at least one other vertebra is firmly united with them (Woodcut, Fig. 1). These form a solid mass, well adapted to support the enormous head. The cup for the occipital condyle is nearly round, and very deep. The rib of the second vertebra is coössified with it, but the third is usually free. The centrum of the fourth vertebra is free, and the remaining cervicals are of the same general form, all having their articular faces nearly flat (Woodcut, Fig. 2).

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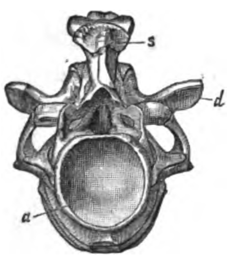

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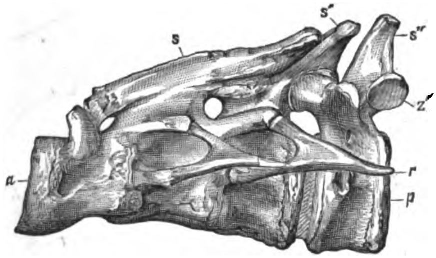

FIG. 1.—Anterior cervical vertebræ of *Triceratops porosus*, Marsh; side view.
FIG. 2.—Fourth cervical vertebra of same series; back view.
a. anterior face of atlas; *d.* diapophysis; *n.* neural canal; *p.* posterior face of fourth vertebra; *r.* rib; *s.* neural spine of axis; *s'.* neural spine of third vertebra; *s''.* neural spine of fourth vertebra; *z'.* posterior zygapophysis.

The anterior dorsal vertebræ have very short centra, with flat articular ends, and resemble somewhat those of *Stegosaurus*, especially in the neural arch (Woodcut, Figs. 3–4).

The posterior trunk vertebræ have also short, flat centra, but the diapophyses have faces for both the head and tubercle of the ribs, as in Crocodiles, a feature not before seen in Dinosaurs (Woodcut, Figs. 5–6).

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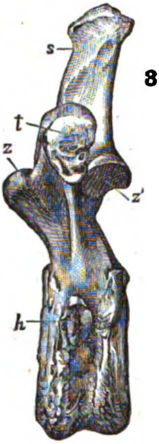

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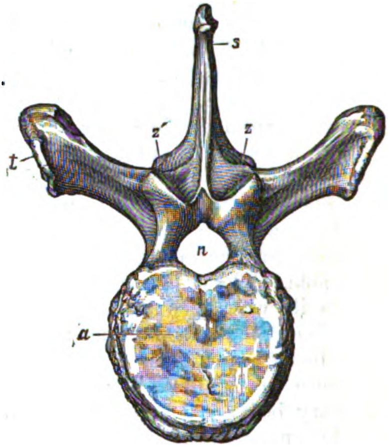

Fig. 3.—Anterior dorsal vertebra of *T. porosus* (side view).
Fig. 4.—The same vertebra (front view).

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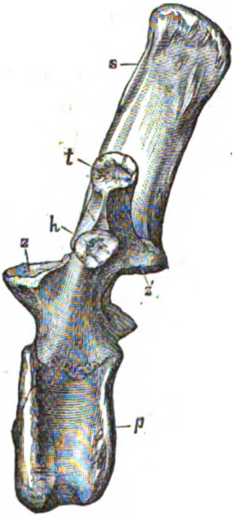

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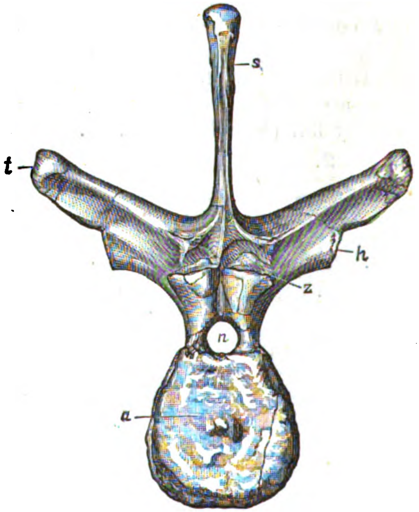


Fig. 5.—Posterior dorsal vertebra of same species (side view).
Fig. 6.—The same vertebra (front view).

The Sacrum.—The sacrum was strengthened by union of several vertebræ, ten being coössified in one specimen of *Triceratops* (Woodcut,

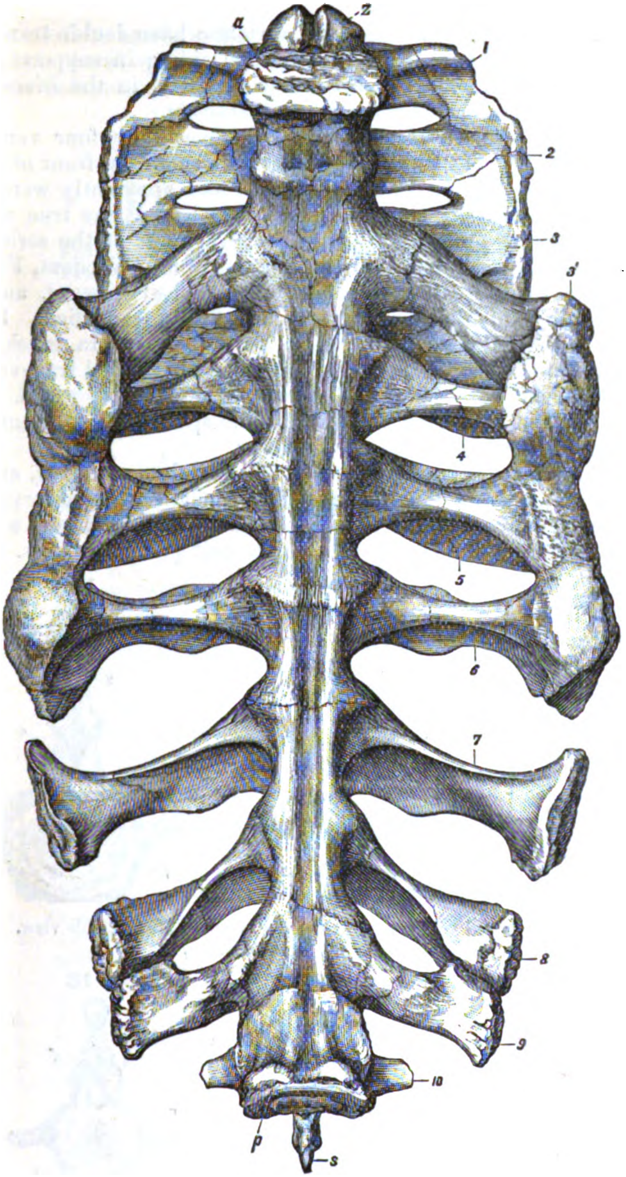


FIG. 7.—Sacrum of *Triceratops porosus*, Marsh,
(Seen from below, one-eighth natural size.)

a. **anterior face of first sacral vertebra; *p.* posterior face of last sacral vertebra; *s.* neural spine of last vertebra; *z.* anterior zygapophysis of first vertebra; 1—10, transverse processes left side.**

Fig. 7). The middle or true sacral vertebræ have double transverse processes, diapophyses being present, and aiding in supporting the ilium. This character has been seen hitherto, in the *Dinosauria*, only in *Ceratosaurus* and some other *Theropoda*.

The main support of the pelvis was borne by four vertebræ, which evidently constituted the original sacrum. In front of these, two others have only simple processes, and apparently were once dorsals or lumbars. Three vertebræ next behind the true sacrum have also single processes, and the fourth, or last of the series, has the rib process weak, and not reaching the ilium (Woodcut, Fig. 7). Seen from the side, the sacrum is much arched upward, and the neural spines of the true sacrum are firmly coössified. In the median region, the sacral vertebræ have their centra much compressed, but the last of the series are widely expanded transversely. The whole appearance of the sacrum is remarkably avian. The neural canal of the sacral vertebræ has no special enlargement, thus differing widely from that in *Stegosaurus*.

The Caudal Vertebræ.—The caudal vertebræ are short, and the tail was of moderate length. The first caudal has the anterior face of the centrum concave vertically, but flat transversely, and a short, massive neural spine with expanded summit (Woodcut Figs. 8–10).

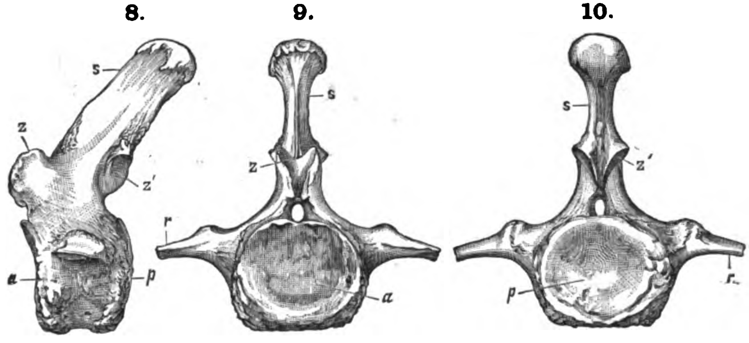


Fig. 8.—First caudal vertebra of *Triceratops prorsus*, Marsh; side view.
Figs. 9, 10.—Front and back views of same vertebra.

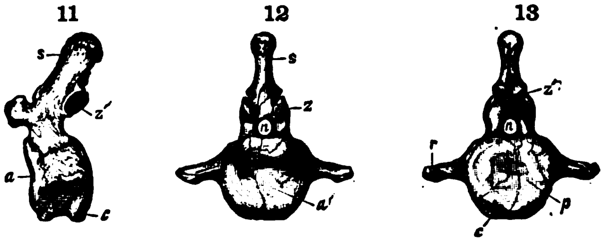
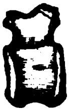


Fig. 11.—Median caudal of same species, side view.
Figs. 12, 13.—Front and back views of same vertebræ.
a. anterior face of centrum; *c*. face for chevron; *n*. neural canal; *p*. posterior face of centrum; *r*. rib; *s*. neutral spine; *z*. anterior zygapophysis; *z'*. posterior zygapophysis.

In the median caudals the centra have biconcave articular faces, and weak neural spines. The distal caudals are longer than wide, with the ends nearly round and concave.

14



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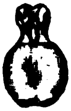

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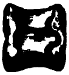
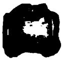


Fig. 14.—More distal caudal of same species; side view.
Figs. 15, 16.—Front and bottom views of same vertebra.

17



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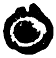

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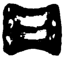


Figs. 17-19.—Distal caudal of same species; side, front, and bottom views.
All the figures are one-eighth natural size.

EXPLANATION OF PLATES.

PLATE IV.—(For Plate IV. see April Number Geol. Mag.)

Fig. 1. Skull of *Triceratops flabellatus*, Marsh (seen from behind).
Fig. 2. Skull of *Triceratops porosus*, Marsh; (seen from the front) *d.* dentary; *p.* parietal; *pd.* pre-dentary; *s.* squamosal; *e.* epoccipital; *h.* horn-core; *q.* quadrate; *h'.* nasal horn-core; *r.* rostral bone.
Figs. 1 and 2, one-twentieth natural size.
Fig. 3. Anterior part of skull of *Triceratops prorsus*, Marsh; side view; one-eighth natural size.
Fig. 4. Front view of same.
Fig. 5. The same; seen from below.
h'. nasal horn-core; *n.* nasal; *na.* narial aperture; *pm.* premaxillary; *r.* rostral bone.
Fig. 6. Pre-dentary of same individual; side view; one-eighth natural size.
Fig. 7. Bottom view.
a. anterior end; *b.* upper border; *d.* groove for dentary; *s.* symphysis.
Fig. 8. Top view of same specimen.

PLATE V.

Fig. 1. Skull of *Triceratops serratus*, Marsh; diagram; seen from above. *d.* epijugal bone; *f.* frontal; *fp.* postfrontal; *j.* jugal; *m.* maxillary; *n.* nasal; *pf.* prefrontal; *pm.* premaxillary; *x.* pineal foramen (one-twentieth natural size).
Fig. 2. Cast of brain-cavity of *Triceratops serratus*, Marsh; side view; one-half natural size.
c. cerebral hemispheres; *cb.* cerebellum; *m.* medulla; *ol.* olfactory lobe; *on.* optic nerve; *p.* pituitary body.
Fig. 3. Maxillary tooth of *Triceratops serratus*; outer view; natural size.
Fig. 4. The same tooth; side view.
Fig. 5. The same tooth; inner view.
Fig. 6. The same tooth; seen from below.

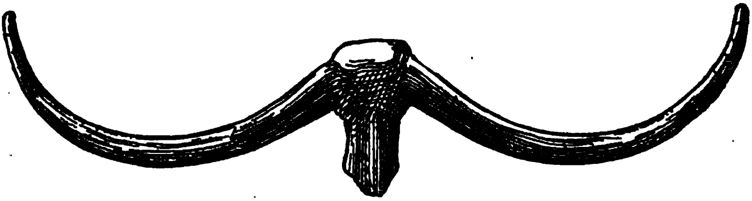
(*To be continued in our next Number.*)

II.—On Bubalus Bainii (Seeley).

By Professor H. G. Seeley, F.R.S., F.G.S., etc.

Very little is known in England of the Tertiary deposits of South Africa. Some marine beds are found, as at Bathurst, where the limestone is full of teeth of *Carchadon* and *Lamna*, and shells of *Turritella* *Ostrea*, *Donax*, and *Lucina*. The shells are preserved in the Albany Museum. I was informed that these beds are 300 to 400 feet above the sea. The teeth shown to me in their worn, polished, yellowish tone rather recalled the condition of Red Crag fossils.

All over the interior of the Colony freshwater Tertiary deposits have filled up ancient valleys, and sometimes existing rivers have cut channels for short distances through these accumulations. I noticed them sometimes to have been partially eroded and again filled up, before modern river denudation laid the existing sections bare. In these older muds and gravels are remains of a terrestrial fauna which no longer lives in Africa. I had no opportunity of determining its antiquity, or of making an approximate list of its fossils; but my attention was called by M. Peringuey to some of these remains in the South African Museum at Cape Town. Besides these newer Tertiary fossils, there are one or two which would be of exceptional interest if their African origin could be established. They are evidently very ancient acquisitions, and the circumstance that they are not mentioned by the elder Bain, and have no mark indicating presentation, refers them to a time too remote for tradition to be helpful. One is the middle portion of a mammalian skull with the teeth worn down to the alveolar margin, which seems to me to be the *Hippopotamus sivalensis* and the trustees have generously entrusted me with the specimen for determination. The skull is rather smaller than the Indian specimens in the British Museum, and the teeth are worn down to the alveolar border, so that characteristic details of dental structure are obliterated. The other specimen is the distal end of the femur and proximal end of the corresponding tibia of an enormous proboscidian. The extremities of these bones had a circumference of about 80 centim. They are as heavily mineralized as Karoo fossils with which they had become associated, and though free from matrix, are so like Siwalik specimens, that it is possible that they may have been brought from India. In this uncertainty I may mention that I once found in a newly unpacked collection of Dicynodont bones from South Africa in the British Museum, an undoubted Mammalian fragment, which was rejected as being a Siwalik fossil, which had accidentally dropped among the other bones. Still the possibility of such a fauna being represented at the Cape is of sufficient interest to justify this reference to specimens without a history.



Cranium of *Bubalus Bainii*, Seeley.

Another mammalian fossil is better authenticated. In the Proceedings of the Geological Society of London, vol. iii. November 20th, 1839, the first evening communication was "Extract from a letter addressed to Dr. Andrew Smith by A. G. Bain, Esq., dated Graham Town, Cape of Good Hope, February 21st, 1839, and communicated by Charles Darwin, Esq. The object of this extract is to announce the discovery by Mr. Martin Smith of the piths and portions of the head of an ox in the alluvial banks of the Moddar, one of the tributaries of the Orange River, and 40 feet below the surface of the ground. The piths with the breadth across the os frontis measured 11 feet 7 inches, but it is calculated that 5 inches had been broken off the end of each tip; and the circumference of the piths at the root was 18 inches. The orbits were situated immediately under the base of the horns. Part of the upper jaw containing five molar teeth, and other fragments of the head, as well as a cervical vertebra, were found at the same time." With time Mr. Bain's estimate of the original size of the horn cores extended. For in the Trans. Geol. Society, series 2, vol. vii. p. 59, the specimen is again alluded to in a letter to Sir Henry de la Beche from Fort Beaufort, April 29, 1844. "From an alluvial deposit on the banks of the Moddar River, before noticed, there was obtained about five years ago the skull of a kind of Buffalo, retaining the bony cores of a pair of horns which it is calculated must have measured full fourteen feet from tip to tip when perfect. This fossil is now in Cape Town." In the same volume of the Geological Transactions, p. 192, is a final reference to another and apparently similar animal. Mr. A. G. Bain in a paper on the Geology of South Africa, read Nov. 15th, 1852, says, "I ought perhaps to mention that I have frequently heard of animal remains being discovered in the alluvium, differing from those of existing animals; and I discovered at Bloemhoff, in the Division of Graaf Reinet, about 10 feet below the surface, in a marly alluvial soil, some remains of an extinct ruminant, consisting of a skull, with the core of one horn attached, the former being of extraordinary length in proportion to its breadth. Its forms part of the collection of 1847 [sent to the Geological Society] and must speak for itseif. I have no doubt a diligent search in the deep ruts or ravines which everywhere intersect the great plains of the interior would produce a vast number of extinct mammalian remains perfectly new to science."

What became of the second specimen is not evident, but I make no doubt that the former is the beautiful ornament which hangs from the gallery in the South African Museum at Cape Town, partly because Mr. Thomas Bain, who assisted in collecting specimens, has always believed that specimen to be his father's fossil, and partly because it agrees with Mr. Bain's description published in 1839. I therefore propose to name it *Bubalus Bainii.*

This Buffalo has the largest pair of horn cores known in the genus. They are remarkable not only for length, but for curvature; the horn bending first forward and then backward in a curve, which lies in one plane, which otherwise rather suggests the form and curvature of Mammoth tusks. The transverse measurement in a straight line between the extremities of the horn cores, which are nearly parallel to each other, is 8 feet 6½ inches measured by M. Peringuey. But on the right side the curve extends 1½ inch further outward from the middle line of the skull than on the left side. M. Peringuey, of the South African Museum, had the kindness to verify for me Mr. A. G. Bain's measurement; and as now preserved the length along the posterior or concave curvature is 11 feet 1 inch, which corresponds sufficiently with 11 feet 7 inches obtained by Mr. Bain probably by taking the outer curve. The horn cores are also remarkably cylindrical, the flattening being moderate, a character of some interest when compared with the flattened form of the horn cores in the large *Bubalus palæindicus* of the Nerbudda. The face is long and narrow, rounded above the orbits, flattened from side to side and concave in length between the frontal and nasal region. The length of the head as preserved is 22½ inches, but with the slight restoration at the back of the head and the lost premaxillary prolongation in front it would be several inches longer. In general character this fossil approaches nearest to the South African Buffalo, so far as can be judged from its state of preservation; and it probably bears much the same relation to that type which the *Bos primigenius* of our own gravels and superficial deposits has to existing British cattle. It is not without interest to find that South Africa is no exception to the general law, that some of the existing races of animals have been preceded by allied species of larger size, as in Europe, South America, and Australia.

I am indebted to a grant from the Government Grant Fund of the Royal Society for the opportunity of identifying the specimen described fifty-two years ago by Mr. Bain. The figure is from a photograph taken for me by Mr. Allis, of Rosebank, Cape Town, and is on the scale of about one millimetre to the inch.

III.—On the Genus *Léveillia* (*Porcellia*, Léveillé), with a Notice of a New Species from the Carboniferous Limestone of Ireland.

By R. Bullen Newton, F.G.S.,
of the British Museum (Natural History).

(PLATE VI.)

IN 1835 M. Charles Léveillé[1] described a peculiar and extinct univalve shell under the name *Porcellia*, which he had discovered in the Carboniferous Limestone of Tournay in Belgium. Since that time the right of this name to stand has never been questioned, notwithstanding the fact of its pre-occupation by Latreille[2] in 1804, for an Isopodous Crustacean genus, and which he rendered *Porcellio*. As the retaining of two names so nearly alike, differing only in their terminal letter, must constantly lead to confusion in Natural History nomenclature, it becomes necessary to suggest an alteration, and

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[1] Mém. Soc. Géol. France, 1835, vol. ii. part 1, p. 39.
[2] Hist. Nat. Crust. 1804, vol. vii. p. 45.

Geol. Mag. 1891. Decade III Vol. VIII Pl. VI.

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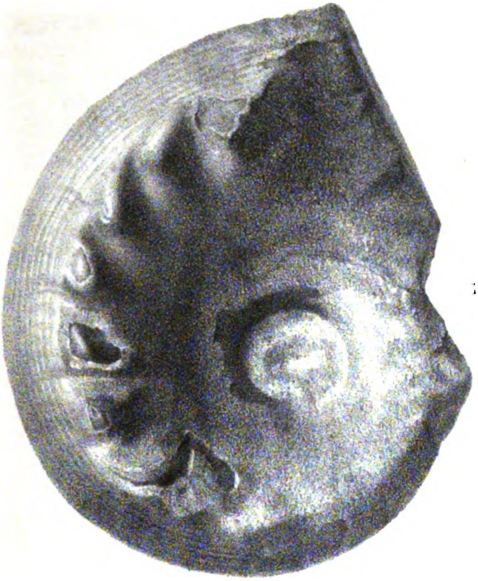

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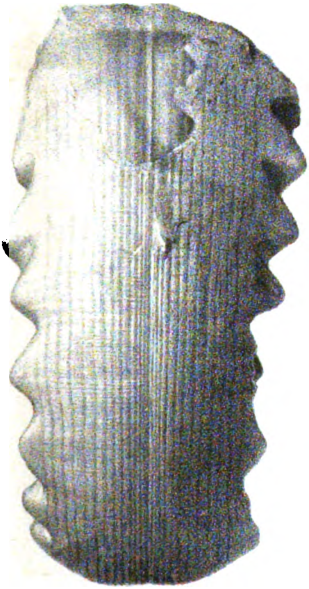

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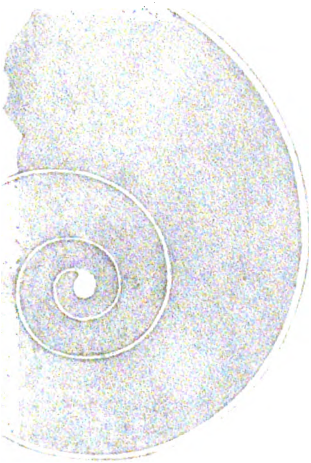

G M Woodward del et lith. West, Newman imp.

Léveillia latidorsata, *sp. nov.*
Carboniferous Limestone. *Ireland.*
(*nat. size.*)

Léveillia is therefore proposed to take the place of Léveillé's genus *Porcellia*.

I may state that my colleague Mr. E. A. Smith, F.Z.S., the Conchologist of the British Museum, warmly supports my action in this matter, and fully admits the justice and desirability of removing *Porcellia* from the list of molluscan genera.

Genus LÉVEILLIA, R. B. Newton, *nom. mut.*
Porcellia, C. Léveillé, 1835, *non* Latreille, 1804.

The chief characters of this genus may be briefly stated as:—Shell nearly symmetrical, monothalamous, discoidal, biconcave; whorls contiguous and on the same plane, except initial ones, which are slightly raised, and all exposed within a wide umbilicus; the dorsal area bears a narrow and centrally situated continuous band, or groove, which opens on the external part of aperture in a slit; aperture oval or quadrangular; surface structure beaded, ribbed, or spirally striated; umbilical margin round or angular, with a series of nodulations or quite plain; shell structure moderately thick.

The distinguished Belgian palæontologist, the late Prof. L. G. de Koninck, published some extended observations on this genus in 1843[1] and 1883,[2] giving a full synonymy and an emended description of the original diagnosis.

Two species were described by Léveillé in illustration of his genus, viz. *Puzo* and *lævigata*. The latter of these being without a slit, De Koninck removed to *Euomphalus* in 1843, and finally to the genus *Straparollus* in 1883, from which fact it is evident he considered the presence of the median band of the highest generic importance, although Léveillé failed to include it among his original characters, recognizing it as only of specific value in his description of *L. Puzo*, the type of the genus. The central position of this band divides the shell into two equal parts. With the growth of the shell the band becomes successively filled up until it reaches the aperture where it is still open to form the slit. The slit itself is often difficult to trace in specimens, but it is usually well seen in the weathered examples from Tournay. Its special function would no doubt be as in other fissured genera for the purpose of ejecting vitiated water from the branchial chambers of the animal.

Generic affinities.—In following the history of this genus we find that much misconception has arisen as to its proper position in the Mollusca. Many of its species have been ranked with the Cephalopoda under *Ammonites*, *Nautilus*, *Goniatites*, etc., though the total absence of septa or chambers is strong evidence against such determinations. Others have been described as *Schizostoma*, *Bellerophon*, and *Pleurotomaria*. With regard to the first of these genera, it may be stated that, possessing no slit, its other peculiarities need not be discussed. On examining *Bellerophon*, or genera known to be closely allied to it, we find it to be usually a heavy globose and convolute shell, with a wide and semilunar mouth, which often bears strong callosities on its inner margins. The continuous fissure is not, however, a persistent character, sometimes consisting of a regular series of isolated perforations, as in *Tremanotus* of Hall; in other species the central part of the dorsal area may be keeled or form a mere depression without apparently any connexion with the interior of the shell, until the lip is reached, when a deep notch is usually present. *Pleurotomaria*, especially its more depressed forms, i.e. *P. mirabilis*, Deslongchamps, presents more striking resemblances to our genus. The whole of the Pleurotomariidæ possess an uninterrupted slit, its position on the test varying greatly in different species. The *P. mirabilis* differs from *Léveillia* in being subdiscoidal and having a wide band excentrally situated, but its surface ornament is very similar in structure and arrangement.

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[1] Desc. Anim. Foss. Ter. Carbonif. Belgique, 1843, p. 357.

[2] Faune Calc. Carbonif. Belgique, 1883, p. 112.

De Koninck,[1] in his latest review of this genus, ranked it with the Haliotidæ, a family peculiar for shells bearing a regularly arranged series of siphonal openings on the *dorsum*. With this determination I am unable to agree, as the continuous slit or groove is decidedly a feature of much importance in our genus. The evidence would seem to justify us in uniting *Léveillia* with the Pleurotomariidæ, thus following the views first adopted by Dr. Ferd. Stoliczka[2] in 1868, afterwards by Mr. R. Etheridge, jun.,[3] in 1878, and Dr. Paul Fischer[4] in 1885. As *Léveillia* and *Bellerophon* have usually been considered to belong to the same family, viz. the Bellerophontidæ, it may not be out of place to examine the systematic position of the genus *Bellerophon* as now understood, it having been, at all times, a question of much dispute among Conchologists. This genus was first established by De Montfort[5] in 1808, and classed under the *Cephalopoda*.

De Blainville[6] in 1825, followed by John Fleming[7] in 1828, regarded it as a Tectibranchiate Gasteropod, and placed it in close proximity to *Bulla* and *Actæon*; but the peculiarities of these shells were so very obvious that this grouping never received much support. Deshayes,[8] in 1830, placed it with the Nucleobranchiata (Heteropoda), and this view has been more generally received than any other, though it seems somewhat anomalous when one considers the delicately formed and small shells of this group, their thin and transparent nature, and the invariable presence of an operculum. It may be observed that no operculum has yet been found in association with either *Bellerophon* or *Léveillia*. De Koninck's researches of 1843 led him to place both these genera among the Prosobranchiates, between *Capulus* and *Pleurotomaria*. The Bellerophontidæ were established by Professor M'Coy,[9] in 1852, as a family of Cephalopoda for the reception of *Bellerophon* only. Later, in 1855, in a further fasciculus of the same work (p. 558), *Léveillia*

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[1] *loc. cit.* p. 10.

[2] Gasteropoda, Mem. Geol. Surv. India, 1868, p. 381.

[3] Cat. Australian Fossils, 1878, p. 87.

[4] Man. Conchyliologie, 1885, p. 848.

[5] Conchyl. Syst. 1808, vol. i. p. 51.

[6] Man. Malacology, 1825, p. 477.

[7] Hist. British Animals, 1828, p. 338.

[8] Encycl. Méthodique (vers), 1830, vol. i. p. 133.

[9] Syst. Desc. British Pal. Foss. 1852, p. 307.

(*Porcellia*) was also included in the family. In 1864, Prof. James Hall[1] described *Tremanotus*, a new Bellerophontoid genus, from the Niagara Limestone of Illinois, which possessed a regular series of siphonal openings on the dorsal region of the shell instead of the uninterrupted band. This discovery led to some valuable observations by the late Mr. F. B. Meek,[2] in 1866, who, grasping the importance of this unusual character in Prof. Hall's genus, looked upon it as the chief link of evidence required to prove the Prosobranchiate affinities of *Bellerophon*, and the desirability of associating it with the fissured shells of that group in close proximity to the Haliotidæ, Fissurellidæ, and the Pleurotomariidæ. It is satisfactory to note that Meek's decision in this matter is at last being recognized with favour, having been adopted by Prof. Karl Zittel[3] in 1882, Mr. R. Etheridge, jun.,[4] in 1882, De Koninck[5] in 1883, Dr. Paul Fischer[6] in 1885, and lastly by Messrs. Nicholson and Lydekker[7] in 1889.

Distribution of Léveillia.—Devonian, Carboniferous, and Triassic Rocks of various localities in England, Ireland, Scotland, Belgium, France, Germany, Russia, America and Australia.

The Triassic species are peculiar to Hallstatt and St. Cassian.

LÉVEILLIA (*Porcellia*) PUZO,[8] C. Léveillé, 1835.

Mém. Soc. Géol. France, 1835, vol. ii. pl. xi. figs. 10, 11, p. 39.

Goniatites intercostalis, J. Phillips, 1836.

Illust. Geol. Yorkshire, Part 2, Mountain Limest. District, 1836, pl. 20, figs. 61, 62, p. 237.

Porcellia Puzo, L. G. de Koninck, 1843.

Desc. Anim. Foss. Terr. Carb. Belgique, 1843, pl. 28, fig. 1, p. 359.
Faune Calc. Carb. Belgique, 1883, pl. 35, figs. 26–28, p. 116.

There is nothing to add to the characters of this type as originally defined by Léveillé, and which have been further added to by De Koninck. A notice of the species here is necessitated by the introduction of Phillips' *Goniatites intercostalis* into its synonymy for the first time. The brief description, as given by Phillips of this species stands thus: "Discoid, whorls costato-tuberculated on the sides, round on the back, with spiral intercostal striæ," and this is accompanied by two figures, one showing a side view with its nodulated whorls, the other exhibiting the size and shape of the aperture, both figures being taken from different specimens preserved in the "Gilbertson Collection," now arranged as one of the separate type series in the Geological Department of the British Museum (Natural History). The presence of the dorsal groove in these specimens, evidently overlooked by Phillips, together with the well-developed nodules bordering the umbilical margin, its highly ornamented surface and quadrangular-shaped mouth, leave no doubt as to its identification with this species.

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[1] Eighteenth Rept. Reg. Univ. New York, 1864, p. 347; Twentieth Rept. 1867, pl. xv. figs. 23, 24.

[2] Note on the Affinities of the Bellerophontidæ, Proc. Chicago Acad. Sciences, 1866, vol. i. p. 9.

[3] Handb. Palæontologie, 1882, p. 183.

[4] Proc. Roy. Phys. Soc. Edinburgh, 1882, vol. vii. part i. p. 73.

[5] *loc. cit.* p. 119.

[6] Man. Conchyliologie, 1885, p. 852.

[7] Man. Palæontology, 1889, ed. 3, vol. i. p. 767.

[8] For a fuller synonymy of this species the student is referred to De Koninck's works as here quoted.

Formation and Locality.—Carboniferous Limestone of Bolland. [Gilbertson Collection, British Museum.]

LÉVEILLIA LATIDORSATA (sp. nov.). Pl. VI.

Specific characters.—Shell large, discoidal, biconcave, last whorl massive and broad; umbilicus wide, deep, with prominent angular-shaped nodules, forming strong marginal serrations; nodules decrease in size towards the younger volutions of the whorls; the ventral surface of last whorl is deep, oblique and furnished with numerous transverse and closely set lines minutely beaded in structure, similar lines cross these concentrically on the younger whorls; dorsal region moderately convex and very broad near the aperture, but gradually diminishing in width towards the nucleus, ornamented with strong and broad ribs, which are crossed transversely by fine closely-set striæ; ribs with a slightly wavy contour and widest near the umbilical margins, decreasing in width and becoming straighter and more numerous as they approach each side of the median groove; aperture quadrangular; groove narrow and prominent; shell structure thick and robust.

DIMENSIONS.

Height	= 40	millimetres.
Transverse diameter	= 72	,,
Height of mouth...	= 30	,,
Width of mouth	= 38	,,
Diameter of umbilicus	= 60	,,

Observations.—This species is distinguished from all others by its large size, a lesser convexity, and greater width of the dorsal region, together with the presence of the broad and prominent ribs over the back instead of the spirally beaded surface. The important angular-shaped nodules, with the deep cavity between each, gives rise to a strongly serrated appearance, especially when the shell is viewed dorsally. Another peculiarity, only shared by one other species, viz. *L. Duponti*, De Koninck, is the fact that these nodules follow the dorsal plane of convexity and extend down the ventral surface only, without forming ridges by being produced over the back as is general in the nodulated species of the genus. The exception mentioned, though possessing this character, has a very differently shaped aperture, and its surface ornament presents the usual spirally beaded structure.

There are three specimens of our species in the British Museum, one of which has been sectioned to show the growth and contiguity of the whorls as well as to prove the monothalamous nature of the genus.

Formation and Locality.—Carboniferous Limestone, Dublin and Kildare. British Museum (Natural History).

References to the Described Species of *Léveillia*; those marked with an asterisk (*) being Represented in the British Museum (Natural History) Collections.

Trias.

Léveillia (*Schizostoma*) *Buchii*,* } Münster, 1841, Beit. Petrefactenkunde,
,, (,,) *costata*,* } 1841, pl. xi. figs. 5, 6, pp. 105, 106.

Locality.—St. Cassian.

Léveillia (*Porcellia*) *Fischeri*, Hörnes, 1855. Ueber die Gastropoden und Acephalen der Hallstätter Schichten. Denksch. k. Ak. Wissen. Wien, 1855, vol. 9, part 2, pl. i. fig. 7, p. 45.

Locality.—Hallstatt.

Carboniferous.

Léveillia (*Porcellia*) **armata**, Murchison, Verneuil, and Keyserling. Géol. Russie Europe, 1845, vol. 2 (Paléontologie), pl. xxiv. fig. 3, p. 346.

Localities.—Orchard; Craigenglen; Craigie (Western Scotland), *vide* Armstrong, Young and Robertson's "Cat. Western Scottish Fossils," 1876, p. 58.

Léveillia (*Porcellia*) *carinata*, L. G. de Koninck, 1883. Faune du Calcaire Carbonifère de la Belgique, 1883, pl. xxxiii *bis*. figs. 27–31, p. 114.

Locality.—Tournay.

Léveillia (*Porcellia*) *Duponti*, L. G. de Koninck, 1883. *Loc. cit.* pl. xxxv. figs. 9–12, p. 118.

Localities.—Pauquys; Ireland (*var.*).*

Léveillia (*Porcellia*) *Le Honi*, L. G. de Koninck, 1883. *Loc. cit.* pl. xxxiii *bis*. figs. 32–36, p. 115.

Locality.—Tournay.

Léveillia (*Porcellia*) *mosana*, L. G. de Koninck, 1883. *Loc. cit.* pl. xxxv. figs. 13–16, p. 117.

Locality.—Visé.

Léveillia (*Porcellia*) *Puzo*,* C. Léveillé, 1835. Aperçu Géologique de quelques localités très riches en coquilles sur les frontières de France et de Belgique.—Description des coquilles, Mém. Soc. Géol. France, 1835, vol. 2, part 1, pl. ii. figs. 10, 11, p. 39.

Localities.—Bolland; Visé; Tournay.

Léveillia (*Bellerophon*) *Verneuili*,* D'Orbigny, 1838. Hist. Nat. Céph. âcetab. 1838, pl. vi. figs. 12–14, p. 212.

Localities.—Bolland; Visé.

Léveillia (*Nautilites*) *Woodwardi*,* W. Martin, 1809. Petrefacta Derbiensia, 1809, pl. xxxv. figs. 4, 5, p. 17.—Mineral Conchology, 1827, pl. 571, fig. 3.—Rech. Foss. Pal. Nouv.—Galles Sud (Australiæ), 1876, pl. 23, fig. 8, p. 319 (De Koninck).

Localities.—Bolland; Winster, Derbyshire; Visé. The original type of this species was refigured by James de Carle Sowerby in the Mineral Conchology, 1827. It now forms part of the "Sowerby Collection," arranged in the Type Gallery of the British Museum. An interesting fact in its distribution is De Koninck's record of its occurrence in the Carboniferous rocks of Burragood, New South Wales.

Devonian (European).

Léveillia (*Porcellia*) *calceolæ*, F. A. Rœmer, 1866. Beitrage zur geologischen Kenntniss des nordwestlichen Harzgebirges.—Palæontographica, 1866, vol. 13, pl. 33, fig. 6, p. 205.

Locality.—Hartz.

Léveillia (*Porcellia* ?) *cincta*, Münster, 1840. *Loc. cit.* 1840, p. 84 (not figured).

Locality.—Elbersreuth.

Léveillia (*Bellerophon*) *cultrata*, D'Orbigny, 1838. *Loc. cit.* pl. 7, figs. 21–23, p. 208.

Locality.—Eifel.

Léveillia (*Bellerophon*) *Edouardii*, D'Orbigny, 1838. *Loc. cit.* pl. 7, figs. 6, 7, p. 215.

Locality.—Eifel.

Léveillia (*Porcellia*) *parvula*, Münster, 1840. *Loc. cit.* 1840, p. 84 (not figured).

Locality.—Elbersreuth.

Léveillia (*Ammonites*) *primordialis*,* Schlotheim, 1820. Petrefactenkunde, 1820, p. 65.—Merkwürdige Versteinerungen, 1832, pl. ix. fig. 2, p. 16. (?) *Schizostoma carinatum*, F. A. Rœmer, 1850. Beit. geol. Kenntniss nord. Harz. 1850, pl. v. fig. 28, p. 38.

Locality.—Winterton, near Grund, Harz. Römer's species appears to be the immature form of *L. primordialis.*

Léveillia (*Bellerophon*) *radiata*, D'Orbigny, 1838. *Loc. cit.* pl. 6, figs. 20–23, p. 216.

Locality.—Eifel; Russia.

Léveillia (*Nautilites*) *Woodwardi*, W. Martin, 1809, *loc. cit.*
,, (*Bellerophon*) *Woodwardi*, J. Phillips, 1841. Fig. Desc. Palæozoic Foss. Cornwall, Devon, etc., 1841, pl. 40, fig. 201, p. 107.

Locality.—Newton, South Devon.

DEVONIAN (American).

Léveillia (*Porcellia*) *crassinoda*, C. A. White and R. P. Whitfield, 1862. Observations upon the Rocks of the Mississippi Valley which have been referred to the Chemung Group of New York, together with Descriptions of New Species of Fossils from the same horizon at Burlington, Iowa. Proc. Boston Soc. Nat. Hist. 1862, vol. 8, p. 303 (not figured).

Locality.—Burlington, Iowa.

Léveillia (*Porcellia*) *Hertzeri*, J. Hall, 1876. Illustr. Devonian Foss. 1876, pl. xvi. fig. 24. Nat. Hist. New York (Palæontology), 1879, vol. v. part 2, pl. xvi. fig. 24, p. 126.

Locality.—Columbus, Ohio (Upper Helderberg).

Léveillia (*Gyroceras* and *Porcellia*) *nais*, J. Hall, 1862. Descriptions of New Species of Fossils from the Upper Helderberg, Hamilton and Chemung Groups. Fifteenth Ann. Rep. Regents New York, 1862, part D. pl. 6, figs. 5, 6, p. 68.

Locality.—Chemung Co. (Chemung Group).

Léveillia (*Porcellia*) *obliquinoda*, C. A. White, 1862. Description of New Species of Fossils from the Devonian and Carboniferous Rocks of the Mississippi Valley. Proc. Boston Soc. Nat. Hist. 1862, vol. ix. p. 21 (not figured).

Locality.—Burlington, Iowa (Chemung Beds).

Léveillia (*Porcellia*) *rectinoda*, A. Winchell, 1863. Descriptions of Fossils from the Yellow Sandstones lying beneath the "Burlington Limestone" at Burlington, Iowa. Proc. Ac. Nat. Sci. Philadelphia, 1863, p. 18 (not figured).

Locality.—Burlington, Iowa.

EXPLANATION OF PLATE VI.

FIG. 1. *Léveillia latidorsata* (R. B. Newton), ventral view of specimen, showing the nodulations and the wide umbilicus. The internal volutions are much covered with matrix.

FIG. 2. Dorsal view of same specimen showing the prominent ribs, the median groove, and the strong marginal serrations. The shell fracture a short distance from the margin of the mouth opening exposes impressions of the ribs and groove in the matrix.

FIG. 3. Internal section of another specimen of the same species showing the thickness of the shell, the contiguity of the whorls and its globular nucleus. The figure also illustrates the monothalamous nature of the genus.

The figures are drawn of the natural size.

IV.—NOTE ON THE AGE AND ANCIENT GLACIERS OF THE HIMALAYAS.

By W. T. BLANFORD, LL.D., F.R.S., etc.

I DO not think geologists who have studied the Himalayas will be disposed to agree with Mr. Howorth (*ante*, pp. 97–104, 156–163) that those mountains have come into existence since the time when the Mammoth flourished in Siberia. It is quite possible that the Himalayas are higher now than they were in Pliocene or even in Pleistocene times; but the geological evidence, so far as it is known, is, I think, in favour of the view expressed by Mr. R. D. Oldham in the GEOLOGICAL MAGAZINE for February (*ante*, pp. 72–73). This view is that the period of elevation has approximately coincided with the Tertiary era. The Upper Pliocene beds along the southern border of the range so closely resemble in material and coarseness those forming in the same area at the present day as to indicate very similar geographical conditions, and Mr. H. B. Medlicott showed, many years ago, that where the great Himalayan rivers flow now, great rivers have flowed since early Pliocene times at least. The principal question in dispute amongst recent investigators of Himalayan Geology has been whether the range existed in Pre-Tertiary times or not. Mr. Howorth's contention that the elevation of the Himalayas is Pleistocene (or, as some geologists call it, Post-Tertiary) has the very great merit of novelty.

Mr. Howorth's principal argument for the recent origin of the Himalayas is founded on the absence of ice-markings on a large scale. On this subject he has brought together a remarkable mass of evidence. It is difficult, without writing a paper of considerable length, to pick out the weak points in this evidence, and to show how much may be said on the other side. I will give one example of each form of reply.

One of Mr. Howorth's principal witnesses, perhaps I should say his principal witness, is the late Mr. J. F. Campbell. Now Mr. Campbell's main object in the paper quoted was to demolish certain rather extravagant ideas, held only by a few extreme glacialists, about polar ice-caps extending to the tropics and similar hypotheses. As a matter of fact, Mr. Campbell never entered the main Himalayan range; he only went to three or four hill-stations on the outer spurs.

On the other hand, Mr. Howorth has overlooked evidence by geologists who really traversed the main range. The only part of the higher Himalayas that I have been able to examine is to the eastward in Sikkim. Here, more than forty years ago, Sir J. Hooker described great moraines in every Himalayan valley that he ascended, at or about 7000 or 8000 feet elevation (Himalayan Journals, vol. i. p. 380). I found the same, and can entirely confirm Sir J. Hooker's observations. The Lachoong and Lachen valleys (which unite to form the Teesta) have, above the lowest moraines, the U-shape and other characteristics of glacier valleys. At the present day, in this part of Sikkim, no glaciers descend below 14,000, and very few below 16,000 or 17,000 feet. Thus great glaciers, in this part of the Himalayas, descended in Pleistocene times from 6000 to 10,000 feet lower than they do now. In

Kashmir, according to Drew and Lydekker (Mem. Geol. Surv. Ind. vol. xxii. p. 32), the case is very similar. In short, so far as I can see, the extension of the glaciers in the Himalayas was very similar to what it was in the Alps; but as the latter are from 15° to 20° farther north, the glaciers came to the base of the mountains, and flowed over some of the adjacent country, whilst in the Himalayas all the ice melted within the range.

The only other fact cited by Mr. Howorth is the curious occurrence of remains of fossil Horses, Bovines, Rhinoceroses, etc., in Hundes. Here, too, I think he has overlooked part of the evidence, as he evidently is under the impression that none of the animals mentioned, Horse, Ox, Deer, Rhinoceros, and Elephant, can live at such elevations as 15,000 feet. The fact is, however, as Mr. Lydekker has shown, that wild horses (*Equus hemionus*) and Oxen (or rather Yaks, *Bos grunniens*) do inhabit Hundes at the present day, that the supposed Deer are Antelopes belonging to the genus *Pantholops*, peculiar to the Tibetan plateau, and that the only difficulty is about the Rhinoceros (the occurrence of *Elephas* is doubtful, I believe). The beds containing the remains are now regarded by Mr. Lydekker (Rec. Geol. Surv. Ind. 1887, p. 54) as Pliocene, not Pleistocene. It is probable that these beds have undergone a certain amount of elevation; but if I were obliged to decide which is more improbable, that a Rhinoceros in Pliocene times lived 15,000 feet above the sea, or that the Tibetan plateau has been raised to that elevation from near the sea-level since the Pliocene period, I should feel very little difficulty in coming to a conclusion.

I am not prepared to accept all Mr. J. F. Campbell's views as to the Himalayas, but there is one remark in his paper with which I thoroughly agree. He infers from the circumstance that what he calls the "waterfall zone" lies close to the sources of the rivers, that the watercourses in the Himalayas are very old. I think if Mr. Howorth had had an opportunity of seeing what is perhaps the grandest example of subaërial denudation in the world, he would be as little inclined as I am to believe that such gigantic furrows as the Himalayan valleys can have been ploughed out by rain and rivers since the frozen Mammoths were imbedded in the gravels of the Siberian tundras.

V.—NOTE ON THE EXPANSION THEORY OF MOUNTAIN-EVOLUTION.

By CHARLES DAVISON, M.A.;
Mathematical Master at King Edward's High School, Birmingham.

THE following is the fundamental principle of the theory of terrestrial evolution which has been sometimes called the "expansion theory":—

Masses of sediment laid down in an area of subsidence are gradually lowered to regions of the earth's crust that are at a higher temperature than that in which they were deposited. The sediment, being heated, expands, is crumpled and folded internally, and, bulging up at the surface, is reduced by denudation to the form of a mountain-chain.

This theory has at different times received attention from geologists, and it has met with a considerable amount of adverse criticism. Much of that criticism appears to me of a very forcible character, but one of the strongest objections that can be brought against the theory does not seem to have been generally noticed.[1]

It is obvious that the heat which passes into and expands the sediment must be withdrawn from the immediately adjoining parts of the earth's crust, partly laterally, but chiefly from below; and that the amount of heat gained by the sediment must be equal to that lost by the crust. The increase in volume of the sediment must therefore be accompanied by an equal decrease in volume of that part of the crust from which the heat has been derived. Thus, the sediment in expanding must follow a crust that is retreating, and this retreat must take place, partly laterally, but chiefly downwards. Instead, then, of the sediment bulging up at the surface, and ultimately forming a mountain-chain, its uppermost layer must remain practically stationary (so far as the effect of the transference of heat alone is concerned), while most, if not nearly all, of the sediment below must subside.

It may, in reply to this, be urged that the sediment will check for a time the natural outward flow of heat from the earth's interior, while the heat will continue to pass as before through the other parts of its surface which are not areas of sedimentation. This may be the case, but the amount of heat so checked cannot be great. Supposing no heat at all to escape for some time through the sediment, then its effect in raising the surface of the mass relatively to that of the earth, can at the very most be represented by the diminution of the earth's radius during that time; and this diminution will be small. The actual relative elevation of the surface of the sediment, if there be any, will of course be very much less than the change of radius.

It follows, then, that the expansion theory is a theory of subsidence, rather than a theory of elevation.

VI.—ON A MICROSAURIAN (*HYLONOMUS WILDI*, sp. nov.) FROM THE LANCASHIRE COAL-FIELD.

By ARTHUR SMITH WOODWARD, F.G.S., F.Z.S.

DURING a recent examination of a collection of fossils made by Mr. George Wild in the Burnley Coal-field, Mr. John Ward, F.G.S., recognized a novelty in the small Microsaurian which forms the subject of the following notes. The specimen was forwarded to the British Museum for determination, and a detailed study of its characters proves it to represent a Microsaurian family that has not previously occurred in the Carboniferous of Europe.

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[1] It has not, however, been overlooked by the Rev. O. Fisher. "The heat conducted into the new deposits," he remarks, "must be abstracted from the couches beneath, so that there can be no absolute increase in the amount of heat beneath the area in question except such as is supplied to it laterally, so that the process must be excessively slow" (Physics of the Earth's Crust, second edition, p. 132). I am indebted to my friend Mr. Fisher for drawing my attention to this paragraph, which, with the exception of the last few words, contains in a condensed form the argument that follows.

The fossil was obtained from the roof of the "Bullion Coal" at Trawden, near Colne, and comprises the head, abdominal region, and base of the tail of a small animal, occupying the whole of an elongated split nodule 0·08 m. in length. The jaw cannot have measured less than 0·017 in length, and the distance between the two pairs of limbs must have been about 0·036. There are also indications that the trunk was comparatively robust, and also somewhat laterally compressed.

Of the *head*, no recognizable portions remain beyond the mandibular rami. The ramus of the left side, imperfect at both extremities, is shown of twice the natural size from the inner aspect in Fig. 1, *md.*, and exhibits some of the conical teeth, which, though robust, have a very large pulp cavity with the walls apparently not folded even at the base. The axial skeleton of the trunk is also unsatisfactorily preserved, the remains of *vertebræ* merely indicating that they were well ossified and not permitting the determination of their characters. Portions of some of the anterior *ribs* (Fig. 1, *r*) prove their stoutness, with an expansion both proximally and distally; but whether they possessed a distinct head and tubercle cannot be determined. Traces of the posterior abdominal and caudal ribs suggest that these were comparatively slender.

The *interclavicle* (Fig. 1, *i. cl.*) is relatively large, and seems to have been rhomboidal in form, though the margins are not well shown. It must have been at least as long as broad, and the exposed surface is distinctly ornamented with radiating rugæ and furrows. Of the pectoral limb there are only obscure indications. In the pelvic arch and limb, however, some of the bones are recognizable, notably the left ilium and femur. The *ilium* (Fig. 1, *il.*) is vertically elongated, with a short expansion below, a mesial constriction, and a gradual widening towards the truncated upper extremity. At its base, part of a thin laminar bone probably represents the ischium. The ilium is almost as long as the *femur* (Fig. 1, *f.*), which, though fractured and perhaps in side view, seems to be comparatively

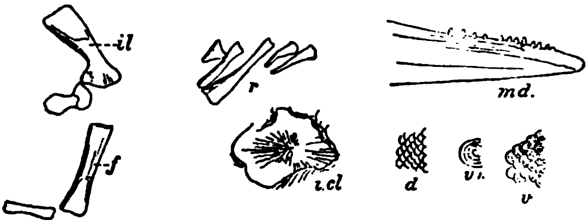

Fig. 1.—*Hylonomus Wildi*, sp. nov.: outlines of bones and dermal scutes.—Coal-measures, Trawden, near Colne. *d.* dorsal scutes; *f.* femur; *i. cl.* interclavicle; *il.* ilium; *md.* mandibular ramus; *r.* anterior ribs (only partially exposed); *v*, v^1. ventral scutes. All the figures of twice the natural size, except v^1., which is enlarged four times.

slender, and must have been terminated at each extremity by unossified cartilage. The *tibia* (? or fibula) also appears to have been slender, equalling about one-half the length of the femur; but its outline is not satisfactorily shown.

The dermal *scutes* cover the whole of the trunk so far as preserved, all being oval in shape, deeply imbricating, and exhibiting prominent concentric lines of growth. Those of the ventral armour (Fig. 1, *v.*) are much larger than those of the dorsal (*d.*); and the former, when magnified (v^1.), show feeble radiating lines either superficial or structural.

The fossil thus described may be assigned without much doubt to the Microsaurian family of Hylonomidæ as restricted by Fritsch.[1] So far as known, indeed, it cannot be separated from the type genus *Hylonomus* itself. The general proportions are similar, and there are the same indications of the laterally compressed form of the trunk; while the relative stoutness of the anterior ribs will also doubtless be proved to characterize the typical species from Nova Scotia when sufficiently well preserved examples are discovered.[2] The closely allied genus *Hyloplesion* of Fritsch[3] is distinguished by its short interclavicle with a long posterior process, by its more slender anterior ribs, and by the relatively smaller size of the ilium; and the remaining genera are excluded from comparison by equally obvious characters. Upon present evidence it is thus proposed to regard the Microsaurian from the Lancashire Coal-Measures as a species of *Hylonomus*; and as this appears to be new, it may appropriately bear the name of *H. Wildi*, in honour of its discoverer, Mr. George Wild, whose long-continued researches in the Burnley Coalfield, especially in connection with the Carboniferous Flora, are well known. Among distinctive specific characters may be enumerated the form and proportions of the mandible and dermal armour; while the precise contour, size, and ornament of the interclavicle will not improbably prove to be of diagnostic value when this element is discovered in the several species from Nova Scotia.

VII.—OBSERVATIONS ON A KEUPER CONGLOMERATE AND ON A BRECCIA, BOTH RECENTLY EXPOSED IN THE NEIGHBOURHOOD OF BRISTOL.

By T. STOCK, Esq.

1. *A conglomerate in the Keuper.*—Whilst a drain was being cut in Argyle Street, joining Upper and Lower Eastvilles, one of the upper beds exposed consisted of a rather fine conglomerate, made up largely of rolled quartz pebbles of small size, compacted with rounded quartz sand and intermixed with coloured fragments (generally very small flakes) of softer shale or clays. I did not measure the thickness very carefully, but I should think that it did not exceed

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[1] A. Fritsch, Fauna der Gaskohle, vol. i. p. 159.

[2] Sir J. W. Dawson, GEOL. MAG. [3] Vol. VIII. p. 152.

[3] A. Fritsch, *tom. cit.* p. 160. *Hyloplesion* is considered to be identical with *Hylonomus* by Credner (Zeitschr. deutsch. geol. Ges. vol. xxxvii. p. 734); but this identification is very doubtful, as lately remarked by Sir J. William Dawson (GEOL. MAG. [3] Vol. VIII. p. 153).

six inches, and as the drain is now filled up, the means of more accurate measurement are lost. The distance from the nearest denuded edge of the Coal-measures is as nearly as possible half a mile. Also, in making a drain-cutting in Heath Street, connecting the two Eastvilles, and about a quarter of a mile nearer Stapleton than the last, but about the same distance from the Coal-measures, another conglomeratic bed was exposed, in which, however, the quartz pebbles were smaller. As the Keuper beds lie horizontally, or nearly so, in this district, the second bed may be a continuation of the first, the altitudes being approximately similar. There is nothing to show that this conglomerate differs much from most others, in respect of derivation. being probably composed of the worn-down materials of preexisting formations, of rocks perhaps for the most part of Coal-measure age. The fineness of the conglomerate would naturally be attributed to its greater distance from the shore. The traces of green clay or shale may be referred with some probability to the Coal-measure shales, which are often variegated in this vicinity and highly coloured, as may be seen in the section at the Easton Brickworks and elsewhere. Apart from the question of conglomerates, I think I have evidence, which requires however to be carefully weighed and reexamined, of the using up of contemporary materials, in the formation of certain Jurassic and Coal-measure shales, in which there was, as is well known, frequent subsidence and elevation. The evidence to which I refer is a few instances in Somersetshire and Gloucestershire of well-preserved fossils occurring upon natural casts of fossils, and the occurrence of what I believe are pebbles of coal.

I may also mention that I have obtained or seen a good many quartz pebbles in the Rhætic bone breccia at Aust; but as I have not access to much of the literature of the Rhætic, I cannot say whether the fact has been noted or not by others before.

2. *A Dolomitic? Breccia in the parish of Alveston, Gloucestershire.*—My friend Mr. Olive, of Greenhill, lately drew my attention to an interesting little section exposed whilst making a boundary-wall on his property. It consists of a series of thin beds lying horizontally, the upper ones being much brecciated, the thick basement bed being homogeneous. The included fragments of the neighbouring Carboniferous Limestone are distinctly angular. being in fact distinctly a breccia, and not a conglomerate. One would naturally suppose that this must be an outlier or continuation of the neighbouring dolomitic conglomerate, which is marked on the Geological Survey Map as running up triangularly to near this spot. If so, it is interesting as an example of a conglomerate passing into a breccia, on account of its closeness to neighbouring Carboniferous Limestone cliffs. The bedding is also interesting, as also its (apparent) horizontality. I do not feel sure whether it may not be a breccia of later age. The matrix is apparently dolomitic, approaching, however, in appearance, some of the Lower Liassic or even Oolitic beds; but I must leave the matter in the hands of more experienced geologists.

NOTICES OF MEMOIRS.

I.—Skuringsmærker og morænegrus eftervist i Finmarken fra en periode meget ældre end "istiden." Udgivet af Dr. Hans Reusch. (Med "An English Summary of the Contents.") Norges geol. undersögelses Aarbog for 1891, pp. 1–11.

Glacial-striæ and Boulder-clay in Finmark, belonging to a period much older than the "Ice Age." By Dr. Hans Reusch, Director of the Geological Survey of Norway.

THE northern shores of the interior of the Varangerfjord, at the far north of the Scandinavian Peninsula, consist of a low range of hills, mainly of sandstone and conglomerate, the beds of this latter rock reaching a thickness of 50 mètres. The conglomerate is entirely unstratified; it is composed of stones and small boulders, about the size of one's head, of Archæan gneiss, granite and diorite, with a slight admixture of fragments of dolomite and quartz, which are irregularly scattered in a ground-mass of reddish clayey sandstone. The general appearance of this rock so much resembled Boulder-clay that Dr. Reusch was induced to search the stones in it carefully, and he found definite well-marked scratches on some of the fragments of dolomite, whilst the surfaces of some of the pieces of harder rock were smooth and even, with traces of striæ. These markings were precisely similar in character to those produced by ice-action on the same kinds of rock in comparatively recent Boulder-clay, and could readily be distinguished from slickenside markings which were found to be present in the conglomerate as well. The evidence of ice-action was further shown by the presence of striæ and grooves on the surface of a hard sandstone immediately beneath the conglomerate, which had been laid bare by the weathering away of this latter. The striæ appeared to belong to two systems, and they could be traced up to and beneath the conglomerate.

The geological age of these ice-marked sandstones and conglomerates has not yet been satisfactorily determined; by Dr. Dahll they are considered as Permian, but Dr. Reusch thinks that they belong more probably to some portion of the Cambro-Silurian series, which prevails so extensively in Scandinavia; hitherto no traces of fossils have been found in them. If this view is correct, the discovery of what appears to be satisfactory and conclusive evidence of the presence of glacial action at this far distant period is a matter of considerable geological interest. In the paper Dr. Reusch gives figures of the scratched stones, with profiles and sketches of the rocks in which they occur.

G. J. H.

II.—Natural History Transactions of Northumberland, Durham, and Newcastle-upon-Tyne. Vol. X. Part II. (1890.)

TWO important contributions to the Geology of Northumberland and Durham, by Mr. Richard Howse, are comprised in the latest part of these Transactions. The first is a short paper on the South Durham Salt Borings, with remarks on the fossils found in the Magnesian-Limestone cores, and the geological position of the salt. Mr. Howse attempts to prove the identity of the Upper Limestone in the salt-borings in South Durham with the Brotherton Beds in South Yorkshire, and the identity of both of these with the Plattendolomit of Germany. He also regards the lowest deposit of Rock Salt as of Permian age. The second contribution is a "Catalogue of the Local Fossils in the Museum of the Natural History Society of Newcastle-upon-Tyne," which occupies sixty pages, and was orginally issued as a separate publication at the time of the British Association Meeting in 1889. This is interspersed with numerous notes on stratigraphy, which are rendered invaluable by Mr. Howse's long experience in the detailed study of the district. The localities from which the specimens were obtained are mentioned under each species, and a reference is given to the record of its occurrence when already published.

III.—DESCRIPTION DES SYÉNITES NÉPHÉLINIQUES DE POUZAC HAUTES-PYRÉNÉES) ET DE MONTRÉAL (CANADA) ET DE LEURS PHÉNOMÈNES DE CONTACT. By M. A. LACROIX. (Bull. Soc. géol. France (3), xiii. 1890, No. 7, pp. 511–58, pls. ix.–xii.)

THE many important contributions to our knowledge of the nepheline syenites made during the past few years by Brögger Tornebohm, Van Werwerke, Derby, and others, have received an important accession in the above Memoir by M. Lacroix. He here describes in detail the nepheline syenites of Pouzac and Montreal and their contact phenomena. At the former the rock is intrusive into a limestone, which is probably Cretaceous; the rock is of especial interest in connection with the alteration products. Thus the nepheline has given rise to (1) zeolites such as mesotype and hydronephelinite; (2) to white mica (gieseckite); (3) to garnets (of the ouwarowite type), which either replace the whole of the nepheline or are developed along the cleavage-planes; (4) to cancrinite; the amphibole (barkevicite) is altered to green mica, and the pyroxene is often surrounded by a zone of aegyrine. On the selvage the rock passes into a variety in which the magnetite, apatite, sphene, etc., and the ferromagnesian minerals (that is to say, those of the first two phases of the first stage of consolidation) are absent, and the sodic minerals (nepheline and sodalite) are replaced by a felspathic microlitic growth; the result is a rock comparable to the tinguaites of Prof. Rosenbusch, which in Brazil and Portugal are regarded as apophyses from nepheline syenite. Dipyre, actinolite, and pyrites occur in the limestone at the contact.

The nepheline syenite of Mont Royal, Montreal, pierces the Trenton limestone, and is itself of Silurian age. It is the principal member of a group of igneous rocks which includes some diabases, teschenites, and porphyrites. The diabases and teschenites both belong to a series resulting from the solidification of the same magma; the teschenites differ from the diabases in the presence of nepheline and sodalite; when olivine also occurs, the rock becomes one of the true teschenites (of Fouqué and Michel-Lévy) or theralites of Rosenbusch.

The normal porphyrites are probably microlitic forms of the diabase, just as the nephelinites with which the former are associated (occurring especially at the Mile End Quarries) are of the teschenites. At St. Anne there is a melilite of the same age as the other rocks of this group—a point of interest, as this variety has hitherto been regarded as confined to the Cainozoic.

The dominant type of the nepheline syenite is a rock with granitic structure and composed of grey or pink felspar, nepheline, sodalite, amphibole, pyroxene, and mica. The complete list of minerals numbers twenty-one, and these are all described in detail; the alteration products are similar to those of Pouzac. There are also some pegmatitic veins. Amongst the most important points in the memoir are those connected with the contact alteration of the rock: at places the normal structure is retained at the junction, but in other cases the rock is profoundly altered for a distance of some metres; the variations afford a complete transition from the granitic (grenu) to the trachytic types of structure, *i.e.* from the normal syenite to the "microsyenite"—a term he proposes owing to the analogy between this rock and the microgranites. The large dyke gives off small branches which traverse the limestone, and these are often composed of many alternating zones of the granitic and trachytic rocks. These dykes further lead to the mica porphyrites; the sodalite and nepheline are absent either owing to original poverty in soda, or to the greater influence of the endomorphic alterations on these thinner veins. The extent of the alteration of the limestone at the contact varies greatly; the minerals developed in the limestone are diopside, wollastonite, garnet, perowskite, and more rarely biotite, sphene, zircon, and felspars. The junction is sometimes marked by a band of cancrinite; but when the felspar is abundant, a zone occurs which may belong to either the eruptive or metamorphic rock.

The memoir is illustrated by twenty-six figures of rock-sections, while the great range in the variations of the rocks is further well brought out by the abundant use of M. Michel-Lévy's formulæ. M. Lacroix, it is interesting to note, rejects at the outset the use of the term elæolite syenite, and he lays special stress in his concluding paragraph on the identity in structure and mineralogical composition of rocks of Silurian age in Canada with those intrusive in the Cretaceous Limestone of the Pyrenees. J. W. G.

IV.—PHENOMENA OF THE GLACIAL EPOCH. PART II. THE GREAT SUBMERGENCE. By DUGALD BELL. Trans. Geol. Soc. Glasgow, Vol. IX. pp. 100–138.

BY this Memoir the author has added another name to the growing list of papers written in opposition to the supposed glacial submergence of England and Wales to the depth of over 1300 feet. He summarizes all the evidence in favour of this view, and then subjects it to a careful examination, with the result of dismissing it as absolutely valueless. A submergence of 500 feet is admitted, but this the author attributes to the elevation of the sea-level by the attraction of the polar ice-cap heaping up the water in the northern latitudes. J. W. G.

REVIEWS.

I.—The Naturalist of Cumbrae. A True Story: Being the Life of David Robertson. By the Rev. Thomas R. R. Stebbing, M.A. 8vo. pp. 398. (Kegan Paul, Trench, Trübner & Co., London, 1891.)

MR. ROBERTSON is well known to geologists through his researches on the Ostracoda and Foraminifera of the later Tertiary or Quaternary deposits; and in these studies he has been associated with Dr. G. S. Brady and the Rev. H. W. Crosskey. The living forms of these minute organisms have likewise engaged much of his attention, and in the course of dredging investigations over a wide area around the British Isles, he has added largely to our knowledge of Marine Zoology and Botany. A very pleasant story of his life is given by Mr. Stebbing in the volume before us, and although Mr. Robertson is still enjoying the fruits of a well-spent life, yet being in his 85th year, his work is practically accomplished, and no apology is needed for the publication of the book.

Born in a humble sphere of life, and losing his father when quite an infant, David Robertson was supported in early years by the labours of his mother, and under these circumstances he received but a year's regular schooling between the ages of 7 and 8. Then he gained employment on a farm in Lanarkshire, and for some years, under different masters, he was engaged chiefly in agricultural work, obtaining an occasional change for short intervals in quarry-work and in the weaving-trade. Thus was he occupied until he reached the age of 24, without having made any position for himself, although all along he was desirous of bettering his circumstances. He gained what education he could by attending night-classes and by the loan of books, whenever any were to be had; and it is noteworthy that the Travels of Mungo Park and the Natural History books of Buffon and Goldsmith thus came into his hands. Two of Robertson's old playmates had now entered the College at Glasgow, as Divinity students, and, remarkable as it seems, he was fired with the ambition to become a Medical student. His friends naturally enough tried to dissuade him; but he obtained an interview with the Anatomical Professor, and received the encouraging assurance that by industry he might accomplish his desires. He resolved to enter the College, and gaining employment with a dyer, whereby he was enabled to support himself in a frugal way, he pursued his studies with zeal. During the next few years (1831-34) he duly attended the College courses, and gained the needful certificates. He subsequently learned Dispensing at a shop in Glasgow, and obtained some practical experience in Medicine and Surgery at the Infirmary.

Now, however, at the age of 30, when ready to go up for examination, circumstances entirely altered his career. He became enamoured of the daughter of the dyer, a maiden who had charge of a crockery-business that belonged to her father. There was the opportunity for Robertson to take charge of a similar business, and it set him meditating on his prospects. He wisely came to the conclusion that business offered him better chances of making an income than the work of a doctor. His friends, as well as the College authorities, now urged him to proceed with his medical work; but he had made up his mind. He married and set up in business, with seven pounds in hand to furnish his house and stock his shop. Right well he and his wife succeeded, so that the business steadily increased. He made journeys to the Potteries and to Hamburgh so as to buy direct from the manufacturers, and by dint of hard work succeeded by the year 1860 in accumulating a sufficient fortune to retire in comfort.

As early as 1837, however, Mr. Robertson began his natural history studies. "Between the years 1850 and 1860 natural history pursuits and business occupations overlapped one another, but the true naturalist 'has no time for money-making,' and accordingly the time came when science extinguished commerce."

He then obtained a house known as Fern Bank, at Millport in Great Cumbrae, an island in the Firth of Clyde. To this island he had frequently gone for relaxation in previous years, and although he continued to reside for some years principally at Glasgow, yet since 1886 the little island has been the permanent home of the Naturalist.

Rather more than half the volume is devoted to an account of Mr. Robertson's scientific labours, of his dredging explorations, and of the Naturalists with whom he became associated; amongst whom Dr. Harvey, Dr. Baird, the Rev. A. M. Norman, Dr. Gwyn Jeffreys, Dr. Dohrn, and others. There are reminiscences of Thomas Edward, whose history, as Mr. Stebbing remarks, tends "to cast something of a sombre gloom over scientific pursuits." He adds, "It is well that it should be seen that there is no necessary connexion between an intense love of nature and a deplorable condition of a man's private affairs." Mr. Robertson, however, was evidently too much of a business man to neglect trade in the pursuit of his hobbies, and after successfully fighting the battle of life, he has done excellent service in the cause of science. H. B. W.

II.—The Perisomic Plates of the Crinoids. By Charles Wachsmuth and Frank Springer. Proc. Acad. Nat. Sci. Philadelphia, 1890, Part III. pp. 345–392, Pls. IX. X. (February, 1891).

THIS paper, although in the importance of the facts which it makes known it can hardly rank with the same authors' recent paper on the ventral structure of *Taxocrinus* and *Haplocrinus*,[1] will nevertheless mark an important advance in the history of Crinoid Morphology.

The authors divide the skeletal elements of a Crinoid into *primary* and *secondary*. *Primary* elements include (*a*) the Abactinal plates, developed on the right antimere and connected with the axial nerve-cords, viz. stem-ossicles, infrabasals, basals, radials, and all brachials, and (*b*) the Actinal plates, developed on the left antimere and connected with the mouth, viz. orals and all plates of the ambulacra. The *secondary* or *supplementary* elements are all the interradial, interbrachial and interambulacral plates, including the anal plates and plates of the tube or sac. These apparently are what they call "perisomic," although the term would seem legitimately applicable only to plates that, one way or another, form part of the calyx.

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[1] "Discovery of the ventral structure of *Taxocrinus* and *Haplocrinus*, and consequent modifications in the classification of the Crinoidea," Proc. Acad. Nat. Sci. Philadelphia, 1888, part iii. pp. 337–363, pl. xviii. (February, 1889).

The title, however, in no way does justice to the contents of the paper. For the authors discuss the homologies first of the plates of the ventral surface generally, secondly of the anal plates; and as side-issues, but important ones, they treat of the interradial plates and of the large plates, hitherto called interradials, seen in the tegmen of the Cyathocrinidæ.

Those who have regarded the question in a purely morphological aspect have long doubted the existence, at least in many cases, of a "*vault*," by which was meant that outer roof of plates supposed, in the Camerata, to conceal another integument, often plated, homologous with the so-called "disk" of an *Antedon*. Thus Dr. P. H. Carpenter in his "Challenger" Report on the Stalked Crinoids (1884), although he still allowed a "vault" to the Actinocrinidæ, could not accept it for the Reteocrinidæ, Ichthyocrinidæ, and most of the Platycrinidæ. The admission of Messrs. Wachsmuth and Springer (Revision III.) that the calyx interradials were continuous with those of the "vault" seemed inconsistent with the presence of other interradials in a supposed "disk" beneath the "vault"; the growth of plates outward and downward from the orals and upward from the interradials, through regions where no connective tissue previously existed, the two meeting in air like a cantilever bridge, was incomprehensible; while the grave statement that the plates of such a "vault" corresponded one for one with the plates of the underlying "disk" (Revision III. 60) showed the untenability of the whole hypothesis. There were—as there are still—certain difficulties in any other explanation; but the paper of Messrs. Wachsmuth and Springer on *Taxocrinus*, etc., furnished so complete a set of links between the "disk" and the "vault" that doubt was no longer possible, and in April, 1890, the present writer denied the existence of any structure covering the disk, and proposed in all cases to use the word *tegmen* (Ann. Mag. Nat. Hist. [6] v. p. 313).

Messrs. Wachsmuth and Springer have now confirmed this conclusion by finding satisfactory homologies for the plates of the tegmen in Actinocrinidæ. The simplest form of tegmen in Crinoids consists of only five plates, interradially disposed, that meet over the mouth and are called *orals*: this is now regarded as also the earliest form. It is supposed that, to increase the calycal cavity, *interradial* plates were developed between the radials, while similar *interambulacral* plates, as well as extensions of the *ambulacral* plates, gradually intervened between orals and radials. The orals might disappear or remain. As the lower parts of the arms became incorporated in the dorsal cup, more and more ambulacral and interambulacral plates naturally came into the tegmen. The plates of the tegmen were at first small and yielding, as in the Ichthyocrinidæ and in most recent Crinoids; in this state when the arms are open the ventral surface is depressed, when they are closed it bulges upwards. To afford better protection to the viscera the tegminal plates became more solid; the tegmen being thus less flexible was fixed perforce in its protruded state. The *covering-plates* of the ambulacra had perhaps been closed from the beginning, but as, through the upswelling of the tegmen, they were now more exposed, further protection was needed. Consequently they were lowered beneath the surface and, starting from the solid orals, interambulacral plates closed in over them. Certain of the covering-plates however, especially, it would appear, the axillary pieces, which perhaps could not so easily be covered by other plates, became much stouter and were still exposed on the surface as solid *radial dome plates.* In any form highly developed along these lines, *e.g. Batocrinus,* the food-grooves, water-vessels and blood-vessels are sunk right beneath the tegmen and are enclosed in a tube consisting of alternating ambulacral or covering plates above and adambulacral or side plates below. The interambulacral plates of the tegmen send curious extensions into the interior of the calyx, and these extensions, spreading out, form what was formerly supposed to be a disk. We may, with Messrs. Wachsmuth and Springer, regard the extensions as caused by the perforation of the plates for water-canals; or we may regard them as simple processes for the purpose of adding strength, without forgoing lightness, by a system of girders.

In the Inadunata Fistulata the dorsal cup never extended beyond the radials, and the tegmen was not developed to the same extent as in the Camerata. The orals did not, however, always persist in the simple stage in which they occur in the Larviformia; in many cases they were, in the opinion of the authors, entirely resorbed, while their places were taken "by large covering plates, of which the proximal ones joined in the center." Ambulacral and sometimes a small number of interambulacral plates occur in the tegmen of the Cyathocrinidæ; besides there are four large plates, one in each interradius except the posterior, which rest against the radials, meet laterally beneath the ambulacra, and may be covered to a varying extent by small interambulacral plates. In the posterior interradius there lies, between the ventral sac and the mouth, a plate often very similar in shape and position to these four. This plate is stated by our authors to be "profusely perforated" in various Lower Carboniferous Cyathocrinidæ, and they state that on either side of it lies a small narrow plate which meets the large plate of the adjacent interradius beneath the ambulacrum. These two narrow plates are quite new discoveries. Once upon a time the five large plates were considered to be orals, a view subsequently abandoned by Wachsmuth and Springer and P. H. Carpenter owing to the passage of the ambulacra *over* and not between the edges of the plates. Wachsmuth and Springer have since then regarded them as interradials; this view they now drop because the plates "support the ambulacra and are covered by perisome," and because in the posterior interradius they do not rest on the special anal plate. They now believe that "the perforated plate is a true anambulacral plate, analogous with the perforated limestone particles at the disk of recent Crinoids," and that the two narrow plates and "possibly also the four larger ones, wholly or in part, are subambulacral plates."

This view is absolutely new and, if proved, of great importance; its adequate discussion is beyond the limits of a review, but we cannot refrain from a few remarks. What do the authors mean by "subambulacral plates"? The term was proposed by Joh. Müller in 1854 for a series of median plates lying beneath the food-groove of *Pentacrinus asteria*, and therefore radial in position like the lancet-plates of the Blastoids. But the plates now under discussion are interradial in position, and only their edges are immediately beneath the food-groove. This difficulty must have been seen by the authors themselves, for they say: "*interradial* plates, as the term denotes, cannot be *subambulacral*." It is hard to see how they better their position by the suggestion that these plates are homologous with the deltoids of Blastoidea, and that they each consist of a median interradial plate fused with two lateral plates that underlie the ambulacra. Not only is this, as they admit, unsubstantiated hypothesis, but if proven, while it would leave an interradial portion still to be accounted for, would not make the lateral portions one whit the more subambulacral, although they might then be considered as adambulacral.

We do not here wish to maintain that the plates are orals, but the authors hardly seem to have given good reasons for the rejection of that view. How do they know that ambulacra cannot pass over the edges of orals? The change may have taken place gradually, and is no more impossible than the sinking of ambulacra. They must show both orals and these interradial plates coexisting in some particular specimen; and this they do appear to state on p. 357: "That the plates are not orals is further proved by the fact that there are in *Cyathocrinus iowensis* other large plates covering the peristome, which naturally represent them." But they do not say how they distinguish the partly resorbed orals from the large covering plates that, in the same specimen (pl. x. fig. 3), are stated to join in the centre.

Then again the plates are stated not to be interradials, because they are covered by perisome; but have the authors ever seen a specimen in which these plates existed but were *entirely* hidden by interambulacral plates? If so, it would have been well to have definitely stated as much; and even then, why should not an interradial plate sink below others until it is covered by them?

Some argument, which we do not follow, is based on the "perforated" plate or "madreporite." Now this plate has been known for some time, and presents all stages of folding, rugosity, and pitting, but that the pits represent pores rests on the statement of these authors. It is a pity that, with their abundant material, they did not cut a single section so as to prove the point. This plate is present in *Euspirocrinus spiralis*, though they speak as if it were absent; on the other hand they state that the ventral tube of that species is "profusely perforated." Now in 1879 they said of it, "Pores have not been observed" (Revision I. p. 143); their present drawings show no pores; in the type-specimens pores are not evident. On what grounds then are we to accept this assertion?

Here we may also note an account of the anus in the Cyathocrinidæ differing from any previously given; and a repetition of their former statement as to its position in the Poteriocrinidæ; but of proof or illustrations never a scrap. Messrs. Wachsmuth and Springer should remember that, in scientific treatises at all events, neither inspiration nor authority can supply the place of evidence and argument.

The latter half of the paper deals with the anal plates. These are not regarded as homologous with the interradials, but are more supplementary still, being "introduced as the case required." They are also distinguished from the plates of the ventral sac or anal tube, a difference of terminology that occasionally seems to make the authors think that there is also some difference in morphology. However, since this idea materially simplifies all discussion as to homology and at once puts some recent speculations out of court, one cannot blame the authors for adopting it. It should, however, be noted that to regard the special anal plate of the Fistulata as a purely supplementary piece, and to suppose that the additional anal plate in such forms as *Poteriocrinus* is a fresh introduction, are ideas wholly different to any previously advocated by these writers. They have also considerably changed their views with regard to *Baerocrinus*. Much of this half of the paper is however unavoidably controversial, and will be more fittingly discussed in another place.

The first half of the paper is also controversial in tone, although, since their own errors were the greater, the authors might well have left Dr. P. H. Carpenter alone. They have, we suppose, got so accustomed to sparring with him that they like to keep it up if only for exercise. This however hardly excuses the gloveless way in which they handle him; while their occasional distortions of his words are rather like hits below the belt. Thus on p. 350 they say: "The ventral pavement of an *Actinocrinus* he calls 'a structure sui generis,' *i.e.* different from that of a *Platycrinus*." Dr. Carpenter's words (Chall. Rep. Stalked Crin. p. 157) are these: "The solid vault of an *Actinocrinus* is a structure *sui generis*, unless, as I believe, its proximal ring of interradial plates is represented by the orals of a Neocrinoid," *i.e.* it is *not* a structure *sui generis*; and Carpenter's homology of the proximal interradials is the very one now adopted by his critics! Again (*op. cit.* p. 178) Dr. Carpenter says: "The peripheral portion of the vault of *Platycrinus*, *i.e.* the zone between the proximal dome plates in the centre and the calyx interradials, is comparatively small; and its interradial spaces are 'occupied by three—rarely five—plates . . . resting upon the interradial of the calyx.' This series of four or six interradials, taken all together, . . . corresponds generally to the single large interradial of *Cyathocrinus*

. . . [*i.e.*] all belong to the same system of interradial plates. . . . Wachsmuth says that 'the first interradial [of the Platycrinidæ] is identical with the outer interradial plate of *Coccocrinus*,' in which I entirely agree." Now see how these plain words are transmogrified on p. 351 of the present paper:—"He regards (p. 178) the peripheral portion of the 'vault,' by which he means the zone between the so-called summit plates and the radials, as generally corresponding to the large interradial of *Cyathocrinus*, and to the single interradial of *Coccocrinus*." We draw particular attention to these misrepresentations, not because we suppose for a moment that they are intentional, but in order that readers of Messrs. Wachsmuth and Springer may not trust too lightly either to their citations or to the charges of misrepresentation that they bring against others.

We think indeed that what was correct in the writings of Dr. Carpenter, not to mention others, might have been more graciously acknowledged; and we would distinctly reprehend the omission of all allusion to Dr. M. Neumayr's explanation of the vault in the Camerata, which appeared in Die Stämme des Thierreiches (1889), and was substantially the same as that now put forward by Messrs. Wachsmuth and Springer. Much, however, may be pardoned in consideration of the extreme interest of the present paper, which, while it knocks the final nail into the coffin of the "Palæocrinoidea," gives promise of many a vigorous discussion in the near future.

The exquisite illustrations to this paper are by two well-known Swedish artists. To the accuracy of the drawings by Mr. G. Liljevall the present writer can bear witness; of their beauty there can be no question. Those by Mr. A. M. Westergren are no doubt equally accurate, but the touch is a little too delicate; plate x. should have been printed in darker ink. Pl. ix. fig. 1, *Cyathocrinus alutaceus*, Angelin, must be referred to *C. ramosus*; fig. 2, *C. lævis*, Ang., is also a *C. ramosus*; fig. 3, *C. lævis*, Ang., belongs to an undescribed species. It is important to note that the originals of figs. 2 and 3 are abnormal in the cup. These changes make no difference to the argument of Messrs. Wachsmuth and Springer; but the references to the figures (p. 356) might be corrected with advantage, the numbers 2 and 3 are interchanged, which is perplexing. Plate x. fig. 15, is not alluded to either in the text or in the explanation of the plate. But our most serious criticism of the drawings is, as said before—*there are not enough.* F. A. B.

III.—CONTRIBUTIONS À LA GÉOLOGIE DES PAYS-BAS—V. LES DUNES INTÉRIEURES, LES TOURBIÈRES BASSES ET LES OSCILLATIONS DU SOL. Par Dr. J. LORIÉ, Archives Teyler, Sér. II. Tome III. 5^e partie. (Haarlem.)

THE Memoir which forms the subject of this notice is the fifth of a series which we owe to the industry of Dr. J. Loiré of Utrecht. It brings the geological record of Holland down to the period of authentic history, in fact, to the present day. In his previously published works the author has brought together an enormous amount of evidence bearing on the question of the later Tertiary earth-movements in Holland. He has shown that there has been extensive, though perhaps intermittent, subsidence in this area during the Pliocene and Pleistocene period; he now attempts to demonstrate that this movement has continued, intermittently and irregularly, since the period of the Roman occupation, and probably down to the present day.

The most interesting part of this Memoir to the English reader probably will be that treating of the changes of the level which have taken place since the Roman period; for though much of the evidence has long been published, it has been so scattered that one is now startled to find what a strong case can be made out for the continuity of the movements of subsidence. Of course Dr. Lorié takes into account the subsidence caused by the slow compression of the peats and clays, as the organic matter decays and the water is squeezed out. But making every allowance for this, there still remains, according to Dr. Lorié, a considerable amount of subsidence unaccounted for. It may be well, however, to point out that no one case of Post-Roman subsidence in Holland appears to be conclusively proved; for the absence of any solid foundations for either ancient or modern buildings leaves it open for any one to suggest bad foundations as the cause of the present low position of the remains. It is the cumulative force of the evidence, all pointing in one direction, that makes the case so strong, especially when the Pliocene and Pleistocene subsidence to the extent of at least 1100 feet is taken into account.

Among the Roman remains found in Holland below the sea-level, the fortress of Brittenburg ("Arx Brittaniæ") was perhaps the most interesting. The ruins were visible at exceptionally low tides during the sixteenth, seventeenth and eighteenth centuries, but have now been entirely destroyed. They showed, according to Dr. Lorié, a sinking of at least three metres since the third century. Another ruin—the temple of Nehalennia in Zealand—was considered by Laveleye to have subsided six or seven metres since it was built. When last seen the floor was at the level of low water, and Laveleye concluded that originally it must have been above the level of the highest tides.

Oaken planks of prehistoric date have been found beneath the peat at a depth of thirteen feet below mean tide, and traces of an inhabited land surface with egg-shells and cut wood at sixteen feet below the surface. By these one is reminded of the traces of a fire found in a submerged forest at low-water level in some excavations for docks at Hull. Belonging to a still older period we find abundance of submerged forests and peat mosses at depths ranging to fifty feet or more below the sea. Much of the remainder of the Memoir is devoted to minute measurements of the amount of subsidence which has taken place since the date of the first accurate surveys. Other portions deal with the origin of the inland sand-dunes, and with the peat mosses. C. R.

IV.—THE GEOLOGY OF THE COUNTRY AROUND LIVERPOOL, INCLUDING THE NORTH OF FLINTSHIRE. By G. H. MORTON, F.G.S., etc. Second Edition. Pp. 287. (George Philip and Son, London, 1891.)

NEARLY eight-and-twenty years have elapsed since the former edition of this work was published. During the interval Mr. Morton has laboured with great enthusiasm and with much patience at the rocks that lie within a distance of about twenty miles from Liverpool. He now gives a particular account of the Carboniferous rocks, to our knowledge of which, and especially of the Carboniferous Limestone of Flintshire, he has largely added. This Limestone is probably the most attractive formation within easy reach of Liverpool, and the palæontology of its several subdivisions has been carefully worked out by Mr. Morton. The Cefn-y-Fedw Sandstone overlies the Carboniferous Limestone, and probably represents the Yoredale Series and Millstone Grit of other districts. These beds and their subdivisions, together with the overlying Coal-measures of North Wales and South-west Lancashire, are duly described. Permian beds occur in some localities near Liverpool; but over much of the area to which reference is made, where the strata are known only from the evidence obtained by shafts and borings, there is a considerable difficulty in distinguishing between Permian and Bunter.

The Bunter Beds, having a thickness of nearly 2000 feet, comprise Lower and Upper Soft Sandstones, with intermediate Pebble-beds. Mr. Morton in describing the Pebble-beds finds it convenient to divide them locally into a lower division with numerous pebbles and an upper division, with few or no pebbles. The Keuper Sandstone and Marl succeed. The Sandstone is of especial interest on account of the "Footprint bed" that occurs (about 124 feet from the base of this division) in the Storeton quarries. Among the tracks are those named *Cheirotherium Storetonense* by Mr. Morton, and they are illustrated in a series of plates. The name of this familiar genus is now unfortunately changed, and the animal is designated *Chirosaurus Storetonensis* (Lydekker, Cat. Foss. Rept. and Amphib. Brit. Mus. Part iv. 1890, p. 216). Footprints of *Rhynchosaurus* are also described and figured.

Some space is devoted to the microscopic characters of the rocks, and to Faults and Denudation; and a number of longitudinal sections are described. Then follow accounts of the building-stones and other economic products, a list of minerals, and remarks on the subject of Water-supply. Some of these matters might better have been treated at the end of the volume, for the author now proceeds to describe the Pleistocene deposits. Among the more interesting of these deposits are those found in the Caves of Ffynnon Beuno and Cae-gwyn that contains relics of "Pre-glacial" Mammalia, or more strictly speaking of forms older than the Boulder Clay of the neighbourhood. Mr. Morton quite agrees with Dr. Hicks in regarding the Mammalia as older than the Glacial Drift, and believes that all the objections raised in opposition to this view have been answered. The Glacial deposits and the Glacial striæ are fully described, as well as the Post-Glacial Peat and Forest-beds, and other Recent deposits; and the author concludes with some brief remarks on the Origin of the Mersey.

The labours of other geologists have received attention, references being made more especially to the papers by Prof. Hull, Dr. Ricketts, Mr. Mellard Reade, Mr. C. E. De Rance, and Mr. A. Strahan. No reference, however, is made to Mr. Mellard Reade's paper on the Physiography of the Lower Trias (Geol. Mag. 1889, p. 549); possibly his views on this subject were considered too heterodox to be mentioned. The author, moreover, has received special help in some instances, Mr. R. Kidston having furnished a valuable list of fossil plants from the Coal-measures of Ravenhead, near St. Helens; and Mr. J. G. Goodchild having contributed notes on some of the rocks found in the Glacial Drifts. Combining as it does the results of long-continued personal observation, Mr. Morton's book furnishes an authoritative guide to the student, and will be of essential service to all geologists who seek acquaintance with the geology of the country around Liverpool. H. B. W.

V.—The Triassic Rocks of West Somerset, and the Devonian Rocks on their Borders. By W. A. E. Ussher. Proc. Somerset Arch. and Nat. Hist. Soc. Vol. XXXV. for 1889. (1890.)

In this paper Mr. Ussher sums up the results of his observations on the Devonian rocks of the Quantock and Brendon Hills, and of the neighbourhood of Porlock and Minehead; and he gives his latest views on the Triassic rocks that border these old rocks near Stogumber, Williton, and Porlock. The sandstones, breccias, conglomerates and marls of the New Red Sandstone series, are all grouped with the Trias; but some changes have been made by Mr. Ussher in his grouping of beds at particular localities. Thus he now recognizes no divisions older than the Keuper, among the New Red rocks west of Williton, and believes that the coarser beds of the Keuper were accumulated higher and higher in the series in that region, progressive subsidence having led to the continuation of marginal deposition.

With regard to the Devonian rocks, Mr. Ussher publishes a table to show their general classification, and the correlation of the subdivisions in North and South Devon with those of Germany, France, and Belgium. In West Somerset and North Devon there is a much greater development of sandstones than in South Devon, for the Cockington Sandstones of the Torquay district, at one time regarded as Upper Devonian, are now placed (together with the Lincombe and Warberry Grits) on the horizon of the Hangman Grits of North Devon. It has been suggested that in North Devon the Foreland Grits and Hangman Grits, which are of similar general character, are the same. Mr. Ussher shows by diagram that this may possibly be the case: but he gives various reasons, sufficient, in his opinion, to negative the supposition that they are identical. The Pickwell Down Sandstones, that were at one time grouped with the Cockington Sandstones, are now placed alongside the Chudleigh Limestone and the Frasnian Beds. The Morte Slates are left in a doubtful position between Upper and Middle Devonian.

The facts brought forward have reference mainly to the distribution of the several divisions and to the faults and flexures to which they have been subjected; and they are illustrated by an excellent coloured geological map.

The author gives an interesting account of his discoveries of fossils in the Lower Devonian rocks of South Devon, and hopes that geologists will be stirred up to look for organic remains in the great Grit-beds of North Devon. The Hangman Grits have yielded *Natica* and *Myalina*: in the Foreland Grits no fossils have yet been detected. The Morte Slates, regarded as unfossiliferous, have since yielded a *Lingula* to Dr. Hicks, so that there is hope for those who will have the patience to spend hours on rocks that are apparently barren, instead of devoting their energies to more tempting strata that are known to be fossiliferous. H. B. W.

VI.—REPORT OF EXPLORATION OF THE GLACIAL LAKE AGASSIZ IN MANITOBA. By WARREN UPHAM. Ann. Rept. Geol. and Nat. Hist. Surv. Canada, Vol. IV. Part E. Pp. 156, 2 Maps, and Plate of Sections. (Montreal, 1890.)

THE suggestion by the late Prof. J. Carvill Lewis that the Boulder-clay of our Eastern counties was formed in a great glacier lake reminded English geologists of the wide extension of such deposits in America. The theory was not a new one in English geology, as it had been used by Agassiz in 1842 to explain the origin of the Parallel Roads of Glen Roy, and has been applied quite recently by Goodchild to the high-level drifts of the Thames Estuary. Mr. Warren Upham, in the above Memoir, has now worked out in detail the evidence for the former existence of a glacier lake in Minnesota and Manitoba compared with which our own sink into insignificance. General Warren, in 1867, discovered that Lake Winnipeg once had a southern outlet, due, he considered, to an alteration in the contour of the country; this view was accepted by Dr. G. M. Dawson and Prof. Dana. Prof. Winchell, however, in 1877, attributed it to the accumulation of water in front of the northern ice-sheet, and two years later Mr. Warren Upham advocated the same theory, and suggested the name of "Lake Agassiz." According to this view, by the recession of the ice-sheet, a number of rivers were enabled to return to their original northerly direction, but as their waters were dammed back by the ice, a series of lakes were formed, the largest being Lake Agassiz. At first the only outlet of this lake was down the Minnesota River to the south, this being the lowest point on the watershed, but as the glacier receded still further to the north, a series of outlets to Hudson Bay were gradually opened. Five beaches were deposited during the former period, and eleven during the latter. The deposits of the lake now cover 110,000 square miles, so that it was larger than the combined areas of the five Laurentian lakes; but it never reached this size at any one time; when the highest beaches of the southern part were being deposited, the northern part was still covered by the ice, and before this district was submerged the opening of the northern outlets had so lowered the water-level that the southern shore had followed the ice to the north. With the final disappearance of the ice-sheet, Lake Agassiz was reduced to a series of scattered lakes, of which Lake Winnipeg is the largest.

The ordinary Glacial drifts of the district are attributed to the action of land-ice, as there is no sign of any transport in or assortment by water. The maximum thickness is 250 feet; the lower part is very hard and tough, but the upper beds are fairly loose and can be dug. The author attributes the difference to the former having been subjected to the enormous pressure of the weight of the ice-sheet, while the latter was merely dropped during the melting of ice. There are many boulders mainly of the Archæan rocks from the N. and N.E.; the largest is 22 ft. by 8 ft. by 14 ft. Striæ are well preserved and their directions are given in an appendix. The more especially lacustrine deposits include a series of sixteen beaches; these are from 25 to 30 rods in width, and rise from 3 feet to 10 feet on the shore side, and from 10 feet to 20 feet on the lake side. There are also a number of deltas and kames and osars: the author uses the two last terms as defined by McGee and Chamberlin; he applies "osars" to the drifts formed in the river-courses, and "kames" to the irregular deposits dropped where the rivers have emerged from between their ice-walled channels and spread out over the adjoining lowlands.

A few freshwater Mollusca of existing species have been found, and some worked flints indicate that man lived on the shores of the lake before the opening of the northern outlets. But the author, quoting a long series of independent estimates, considers that this was less than 10,000 years ago.

It is found that the beaches ascend as they are traced to the North, the amount varying from one to sixteen inches to the mile: he concludes—accepting Mr. R. S. Woodward's calculations—that a quarter of this was due to the heaping-up of the water by the attraction of the northern ice-sheet. After a careful consideration of Chamberlin's hypothesis of alterations of level being due to contraction of the earth's crust consequent on the lowering of the isogeotherms by a glacial climate, it is rejected as inadequate, as its influence would be the reverse of that which has taken place in the Lake Agassiz area.

The memoir closes with a chapter on the "Geologic and Agricultural Resources" of the district. It is illustrated by a couple of maps and a plate of sections; but further illustrations will no doubt be given with the more detailed description to be given by the author in one of the Monographs of the United States Geological Survey. The exploration, it should be added, was undertaken, on behalf of the Geological Surveys of the United States and Canada, both of which may be congratulated upon an arrangement whereby, in defiance of International Boundaries, the whole work was entrusted to one man, and also upon having secured the services of a geologist whom a long training in glacial geology had rendered especially competent for the task. J. W. G.

VII.—Aids in Practical Geology. By Prof. Grenville A. J. Cole, F.G.S. 8vo. pp. 402. (London, Charles Griffin & Co., 1891.)

PROFESSOR Grenville Cole's "Aids" is a work occupying an unique position in geological literature. Every one trained in the modern school of Geology has a vivid recollection of the numberless sources from which he was compelled to select the various necessary items of information. Apart from ordinary geological text-books, there were works on chemical analysis, qualitative and quantitative, on blowpipe analysis, mineralogy, and general physics, technical treatises and memoirs on the microscopical examination of rocks, and various other less important references too numerous to mention. He was continually dependent upon the Professor for advice and help; and he was led most emphatically to realize the extraordinary combination of scientific methods that is requisite for the satisfactory study of a geological formation. The new volume before us dispels all these difficulties, and now, for the first time, renders it possible even for an ordinary amateur to gain an adequate knowledge of the subject up to date. Not only is this the case, but many of the open paths for further investigation are incidentally pointed out, with sufficient references to original memoirs to enable an enthusiastic student to proceed far in this direction.

Prof. Cole is throughout eminently practical. Several guides to the beginner in Field Geology have already appeared, but we have never met with so concise a series of useful hints as to small matters that most geologists have to learn by experience, as can be found in the first part of the present work. Not only is the equipment discussed in a manner that betokens wide experience, but the most precise information is afforded as to the best form of gymnastics for various difficult circumstances, such as the crossing of streams and the scaling of crags. In the remarks on packing specimens, again, even such minutiæ as the peculiar Parcel Post regulations of Italy are briefly noticed; and in this section of the book, as in the others, scarcely an instrument is mentioned without some allusion to its cost, its comparative efficiency, and the name of the maker from whom it can be obtained. In many instances, directions are given for the construction of simple apparatus from common materials, such as gallipots, corks, and wire; and the circumstances of travellers in regions distant from ordinary civilization are always carefully remembered.

The second part of the book is devoted to the examination of minerals, forming not merely a concise statement of the ordinary methods of determinative mineralogy and an index to the characters of the species of most common occurrence, but also comprising numerous hints and cautions which the student will soon learn to appreciate. Two conspicuous features are the elaborate treatment of the determination of specific gravities, and an interesting chapter on Szabó's method of quantitative flame-reactions for the felspars and their allies. After these preliminaries, the most important part of the work, relating to the examination of rocks, immediately follows. Rock-structures are first treated in a general way, the principal characters and varieties of several groups—the coarsely fragmental, ordinary stratified, cleaved, foliated, and igneous—being successively pointed out. The determination of the specific gravity, fusibility, and chemical composition of rocks, is next considered; and an important chapter on the isolation of the constituents of rocks is followed by a short and practical discussion of the petrological microscope and the preparation of rock-sections. With the chapter on the more prominent characters to be observed in minerals in rock-sections, and the following synoptical remarks on the appearance of thin sections of the chief rock-forming minerals, the student enters upon a subject that requires long practice for its adequate comprehension; but Prof. Cole's "aids" are among the most valuable that have hitherto appeared, including, indeed, some items that have scarcely yet reached ordinary handbooks, and numerous notes in special type when there is any possibility of doubt or misinterpretation. The sedimentary rocks, as usual, occupy a comparatively small amount of space, but all the latest discoveries relating to them seem to be duly incorporated in the synopsis. The igneous rocks are treated with remarkable elaboration, and students will be grateful to the author for presenting so concise a summary of the main facts with a comparatively simple nomenclature. As Prof. Cole remarks, "petrography has of late suffered from the introduction of an abundance of new terms, and, what is far worse, of old terms defined in new senses; but the majority of these can be avoided by the use of familiar adjectives or mineral prefixes, to the great lightening of the science." The Holocrystalline Igneous Rocks are subdivided into the six groups of Granite (with Eurite), Syenite, Quartz-Diorite (with Quartz-Aphanite), Diorite (with Aphanite), Olivine-Gabbro (with Olivine-Dolerite), and Peridotite. The Lithoidal Igneous Rocks, with some glassy matter, are classified as Rhyolites, Trachytes, Rhyolitic Andesites, Andesites, Olivine-Basalts, Limburgites, and Hemicrystalline Nephelinites (with Leucitites). The Highly Glassy Rocks comprise the Obsidian and Tachylyte Groups. In the case of every term, a reference to its original definition is given, with frequent notes upon subsequent changes in its meaning; and a table is added exhibiting the relationships of the various types, so far as determined.

The chapter on Metamorphic Rocks is characterized by much caution in alluding to theoretical matters, and the definition of the limits within which the term "metamorphic" is applicable is well stated to be a "matter of opinion." Prof. Cole places in this category all rocks in which new crystalline developments, or new structures, or both, have arisen under the influence of subterranean heat, or pressure, or actual earth-movement. He seems, moreover, to show more sympathy with the original views of "regional metamorphism," than with the recent speculations of those who regard the Archæan rocks as unique among geological formations. In referring to the so-called "true schists," for example, he remarks "that the alleged distinction between schist-like rocks and schists of Pre-Cambrian age requires such great delicacy of definition that the majority of observers must be content to use the word 'schist' in its wide practical signification, covering all well-foliated rocks, of whatever age, which fall short of the coarser and more felspathic type styled gneiss."

The final section of the work is devoted to the examination of those fossils which are of especial value for stratigraphical purposes. The Invertebrata alone are treated, and an attempt is made to define in scientific terms each of the more conspicuous genera, often with an illustrative woodcut. This plan is a great improvement upon the time-honoured custom of recording lists of names of fossils with merely incidental allusions to their characters, of which occasional figures are supposed to give an adequate conception. The subject, however, is so vast that we doubt whether Prof. Cole's brief outlines will in many cases suffice for the requirements of an ordinary worker in unknown regions, and we trust that some day the scheme may be further elaborated.

It is difficult to criticize a work of this nature; every specialist will hold his own opinion with regard to the particular section that concerns his own line of research. We are inclined to think, however, that in some instances simple matters might have received more attention. In certain strata, for example, a sufficiently accurate determination of the true dip can readily be made by employing a spirit level to ascertain the line of strike and fixing the clinometer at right angles to this, without any of the geometrical constructions such as Prof. Cole alone describes. But we have most serious fault to find with the publishers. In a work so admirable both in subject-matter and typography, the coarseness and inartistic character of so large a proportion of the new figures is a blemish of which it is impossible to speak too harshly. In this respect, it forms a striking contrast to the scientific handbooks issued by publishers abroad, and we trust that in the next edition the fault may be entirely remedied. That such an opportunity will soon present itself we are fully assured, for the volume is one that will prove invaluable and be welcomed by all students of Geology.

VIII.—THE GEOLOGY OF BARBADOS. By J. B. HARRISON and A. J. JUKES-BROWNE. 8vo. pp. 64 and Map. (Published Barbadoes? 1890.)

SO long as it is argued that the Glacial period in England was due to the diversion of the Gulf Stream will geologists feel interested in all investigations upon the later Tertiary geology of the West Indies. The island of Barbados moreover, possesses an additional source of interest in the Radiolarian deposits so long noted for the beauty of their fossils, and now of especial value from their bearing on the question of the permanence of oceans and continents. We must, therefore, feel much gratitude to the authors of this memoir for the care with which they have worked out the geological structure and past history of Barbados, and for the first time definitely established the relations of the series of deposits of which it is composed.

Barbados is an island some 21 miles long by 11 broad and rising at one point to a height of 1104 feet It is situated at a distance of 100 miles from the main chain of the Lesser Antilles, from which it is separated by a sea 1500 fathoms deep. It is composed entirely of sedimentary deposits, no volcanic rocks occurring on the island except a little light dust and pumice which was probably ejected from a vent within a radius of 300 miles; the authors, however, suggest that the elevation may have been due to a laccolite. The absence of volcanic rock is a point of importance, as we have been taught on high authority "that all the Lesser Antilles almost without exception are volcanic."

The rocks are divided into four groups: the Scotland series, the Oceanic series, the Coral limestones and the valley deposits and blown sand. The first consists of an irregular series of sandstones, grits, and shales, with some bituminous clays yielding petroleum, resembling those of Trinidad and Venezuela; the whole series is much contorted, faulted and even inverted; they are shown to be more than 600 feet thick, while their base is not seen, and they are unconformably overlain by the succeeding beds. Fossils are very rare in this series, and they are so imperfectly preserved that all the authors can conclude is that they have "general resemblances to the fossils in those deposits of Trinidad which are regarded as Miocene" (p. 15).

The Oceanic series overlie these unconformably; the basement bed is a hard blue limestone, a fact of very considerable importance on the question of the deep-sea origin of the succeeding 300 feet of chalky earths, limestones, Radiolarian marls, and red clays. The evidence of both lithology and palæontology is conclusive as to the deep-sea nature of the deposits; thus the Foraminifera indicate a depth of 1000 fathoms, the Echinoid of more than 1000, while the Radiolaria point to still deeper conditions. The evidence as to age is less satisfactory: the Microzoa are of little value in this connexion; while of the higher fossils the only one that has been fully worked out is a specimen of *Cystechinus crassus*, Greg. The authors, therefore, merely quote the opinion of the describer of this fossil, that it was either of Pliocene or Pleistocene age.

The *Coral Rocks* form a sheet that covers 144 out of the 166 square miles of the island; it is rarely more than 200 feet thick, but it is in places as much as 260 feet. The coral rock is merely a rough coarse-grained limestone; beds of freestone, a very porous building-stone, locally known as dripstone, and some intensely hard compact rock that forms good road-metal, also occur. Much of the coral rock is formed of broken fragments of Corals, Mollusca, and Nullipores. The base of the series is always of loose rubble or half-consolidated coral or marl. In one of the caves opened by the Water Supply Company, the coral rock is seen to rest on a mixture of coral sand and material derived from the siliceous earth: none of the deposits that one might expect to find on Dr. Murray's hypothesis seem to be present, as none such are referred to. The corals and shells examined show that the whole series is of Pleistocene age.

Of the four concluding chapters, one gives an outline of the physical history of the island from the continental conditions indicated by the Scotland series till the recent elevations; a second is devoted to the general configuration and drainage, a point of much interest in connexion with the recent operations of the Water Supply Company, under the able guidance of Mr. E. Easton, C.E., F.G.S., in intercepting the underground water-courses. The final chapters are on the soils and surface deposits and contain an account of the economic products of the island.

The memoir is certainly a most valuable contribution to our knowledge of the geology of the Caribbean area; but it must be judged not so much as a scientific monograph as a popular guide to the authors' geological map of the island. Its treatment of the scientific problems involved is only preliminary to the series of more detailed papers to be published elsewhere. But the work is so simply and interestingly written, and the points upon which further evidence is wanted so clearly indicated, that it ought to stimulate the residents of Barbados to a more careful search of the lower beds, and thus enable the authors to settle more definitely the age of the Scotland series, which is the most important problem that still awaits solution. J. W. G.

IX.—NORTH AMERICAN CRETACEOUS ECHINOIDEA.

NOTE SUR QUELQUES ÉCHINIDES DU TERRAIN CRÉTACÉ DU MEXIQUE. Par G. COTTEAU. Bull. Soc. géol. France [3] xviii. pp. 292–99. Pl. I. II. (Paris, 1890.)

A REVISION OF THE CRETACEOUS ECHINOIDEA OF NORTH AMERICA. By W. B. CLARK. Johns Hopkins University Circulars, No. 86. 1891. 8 pp.

THE paucity of marine Mesozoic deposits in North America is in striking contrast to the extensive development of those systems in Western Europe; hence every addition to the fauna of those "ages" on the other side of the Atlantic is of great interest to European geologists as supplying further material to assist in the study of the evolution of the same group in the two provinces.

The Echinoidea have been especially neglected; hence both M. Cotteau and Mr. Clark are able to make most valuable additions to the North American fauna; the literature of the group moreover is very scattered and most of the species have been described by men who were not specialists, so that a revision of the genera was greatly needed.

In M. Cotteau's paper is given a careful description of six species from Mexico; two of these, viz. *Diplopodia malbosi* (Ag.) and *Salenia prestensis* (Gras), are characteristic of the European Aptien. Three of the other species are of European genera, viz., *Pseudocidaris saussurei*, Lor., *Holectypus castilloi*, Cott., and *Enallaster mexicanus*, Cott.; the last two are new species; the first was originally based by M. de Loriol on spines, but the test has been described by M. Cotteau. The sixth species is that described by D'Orbigny as *Echinoconus* (*Galerites*) *lanieri*, but for which Prof. Duncan in his

"Revision" established a new genus, *Lanieria*; with this course M. Cotteau fully agrees. The last species may be of Tertiary age, but the others are all Lower Cretaceous.

Mr. Clark's "Revision" contains a list of the species hitherto described, with short notes on the synonymy. The list includes 43 species, of which 19 are new; several old species are merged as synonyms, and some are abandoned as indeterminable. As Mr. Clark does not accept Roemer's genus *Macraster*, not one genus in the list is peculiar to America; while none of the species recorded are found in Europe. *Goniopygus* and *Botriopygus* are now added to the American fauna, and it is interesting to note that the author identifies one species as a *Psammechinus.* The paper is preliminary to a detailed monograph, and its issue was a very wise course, as in a group in which the literature is so scattered, it was the only means of enabling the work to be made fully complete.

J. W. G.

REPORTS AND PROCEEDINGS.

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Geological Society of London.

I.—Feb. 25, 1891.—A. Geikie, Esq., LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "A Contribution to the Geology of the Southern Transvaal." By W. H. Penning, Esq., F.G.S.

The following table shows the author's classification of the sedimentary rocks of this region, as compared with those of Messrs. Dunn and Stow and Prof. Rupert Jones:—

Dunn. (Map, 1887.)		Stow.	T. R. Jones.		Penning.		
Coal-measures: *Upper Karoo* (formerly Stormberg Beds, above Upper Karoo).	Carboniferous to Triassic.	*Upper Karoo.*	*Lower Karoo.*	Triassic Formation.	*High Veldt Beds*		Oolitic.
Kimberley Shales: *Lower Karoo* (formerly Upper Karoo).		......			*Kimberley Beds.*		
	Silurian.				*Klip River Series.*	*Megaliesberg Formation.*	Devonian.
Lydenburg Beds.					*Witwatersrand Series.*		
Namaqualand Schists.					*De Kaap-Valley Beds.*		Silurian.

The De Kaap-Valley Beds consist of schists, shales, cherts, and quartzites, with some conglomerates, chloritic and steatitic beds of great thickness, faulted, according to the author, against the granite. They contain a few obscure Corals, and are provisionally referred to the Silurian.

The Witwatersrand Series consists chiefly of sandstones, shales, cherts, and quartzites, having an estimated thickness of 18,000 feet, possibly formed in a hollow of the granite, and perhaps of marine formation.

The Klip-River Series is formed of shales, flagstones, cherts, and quartzites, with numerous interstratified traps, and is at least 18,000 feet thick. Near its base is the "Black Reef" and a chalcedonite like that described by the author in connexion with the Lydenberg district, which confirms his opinion that this area is formed of part of the Megaliesberg formation. The base of the series is generally conformable to the underlying rocks. The whole of the lower half of the Megaliesberg formation is let down against the north side of the granite south of Pretoria.

The author divides the formation which he described in 1884 under the heading of High-Level Coalfields of South Africa into the Kimberley Beds and the High Veldt Beds. The former thin out eastward, and are overlapped by the latter, the estimated thickness of which is 2300 feet. A volcanic rock overlies the Coal-formation. Near the base of the formation is a bed of loose, calcareous, sandy clay inclosing many waterworn pebbles, some of large size, derived from the quartzites and "bankets" of the underlying formation. The author is convinced that the region was under glacial influences at some time during the long period which intervened between the deposition of the Megaliesberg formation and of the coal-bearing rocks of the High Veldt, which latter, he maintains, are certainly Oolitic; the latter contain *Glossopteris* (?) and Fishes, which he considers to be nearly allied to *Lepidotus valdensis*, the latter being from the Free State.

The High-Veldt rocks are of fluviatile origin, and there appears to have been continuity of fluviatile denudation from the close of the Oolitic period until now.

2. "On the Lower Limit of the Cambrian Series in N.W. Caernarvonshire." By Miss Catherine A. Raisin, B.Sc. Communicated by Prof. T. G. Bonney, LL.D., F.R.S., V.P.G.S.

In this paper the author examines the questions, whether the Bangor beds should be included in the Cambrian series, and how the strata associated with the southern felstone should be classed. The lithological character of the rocks overlying the conglomerate at Bangor is shown to be of little classificatory value, but the apparent discordance between its strike and that of the beds beneath suggests the inclusion of the latter in the pre-Cambrian series, as maintained by Prof. Hughes and Prof. Bonney.

The age of the northern beds must depend, however, to a great extent upon the classification adopted for the Llyn Padarn rocks. It has recently been proposed to regard the felstone of this district as a lava-flow of Mid-Cambrian age, and the beds to the north as lower strata included in the same great series. The author points out as objections to this view:—(1) the enormous thickness of beds, which in that case must be cut out by the supposed Arenig unconformity at Caernarvon; (2) the difficulty of assigning two felsite masses lithologically similar to two distinct periods; and (3) the occurrence of conglomerates similar to those which are elsewhere admitted to be basal Cambrian. But in addition to these minor difficulties, the theory of a Mid-Cambrian age for the above-named lava is shown to be without foundation. It was supposed that in the Bryn Efail quarry the slaty rocks of the district immediately to the north could be seen in contact with, and altered by, this lava. The author shows that no slate occurs in the quarry, a diabase having apparently been mistaken for it, and that there is no grit in the section which would afford any support to the new theory. The author concludes that the Llyn Padarn felsite is probably, as classed by Dr. Hicks and Prof. Bonney, of pre-Cambrian age. As regards the country to the north, the argument for the new arrangement was based mainly on the interpretation of the Bryn Efail rocks; but as this is seen to be erroneous, the section founded on it does not appear preferable in any way to that published by the Geological Survey.

3. "On a Labyrinthodont Skull from the Kilkenny Coal-measures." By R. Lydekker, Esq., B.A., F.G.S.

The author describes a skull from Jarrow Colliery, which he refers to *Ichthyerpetum*, and names *I. hibernicum*, giving reasons for its specific distinctness from *I.* (*Erpetocephalus*) *rugosum*, Huxley. He compares it with allied forms, and believes that it is a member of the group *Brachyopina* of Miall, and if so that we have a number of forms belonging to a type which is unknown above the base of the Permian in Europe, but which survived to later times in the Indian, Australian, and Ethiopian regions.

II.—March 11, 1891.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "Manod and the Moelwyns." By A. V. Jennings, Esq., F.L.S., F.G.S., and G. J. Williams, Esq., F.G.S.

The area described by the authors is on the N. side of the Merionethshire anticlinal of Lower Cambrian rocks, and contains Lingula flags, Tremadoc and Arenig rocks. The authors correct what they think is an inaccuracy of some importance in the correlation of beds in different parts of the range, as interpreted in the map and memoir of the Geological Survey, and trace with greater completeness the position and constancy of the beds of slate in the Arenig series—a point of considerable local and practical importance to those engaged in slate-quarrying. They offer also what seems to them to be conclusive evidence to show the intrusive nature of the great crystalline mass known as the syenite of Tan-y-Grisiau, and to its intrusion are due, in their opinion, the peculiar physical characteristics of the surrounding country. Though in the immediate neighbourhood of Festiniog there is no direct evidence of unconformity between the Tremadoc and Arenig series, it seems probable that an unconformity does exist; for when traced toward the west the Tremadoc beds thin out and the Lingula flags are overlain by Graptolite-bearing slates of Arenig age, while eastward, near Llyn

Serw, the grit comes close upon Upper-Lingula flags. The division of the Arenig volcanic rocks into Lower Ashes, Felstone, and Upper Ashes, while true of some districts and useful as a generalization, conveys an idea of uniformity of strata all round the anticlinal which more detailed examination of different districts does not support.

2. "The Tudor Specimen of *Eozoon.*" By J. W. Gregory, Esq.

After careful examination of all the slides and figures, and after consideration of Sir W. Dawson's interpretation, the author is absolutely unable to recognize in the specimen any trace of the "proper wall," "canals," or "stolon passages" which are claimed to occur in *Eozoon,* or any reasons for regarding the calcite bands as the "intermediate skeleton" of a Foraminifer. There are points in Sir W. Dawson's figure which might pass as "stolon passages," but they appear very different in a photograph, and the specimen agrees with the latter.

The author, however, gives reasons for concluding that the case against the organic origin of the Tudor specimen does not rest on negative evidence alone; for though the rock is much contorted, the twin lamellæ and cleavage-planes of the calcite are not bent; and the fact that the crystalline bands cut across the bedding-planes further shows their secondary origin.

The rock in which the specimen was found is not "Lower Laurentian," and is included by Messrs. Selwyn and Vennor in the Huronian.

III.—March 25, 1891.—Dr. A. Geikie, F.R.S., President in the Chair.—The following communications were read:—

1. "Notes on Nautili and Ammonites." By S. S. Buckman, Esq.

1. *The Position of the Last Septum.*—Mr. Bather's theory of shell-growth in Cephalopoda (Ann. and Mag. Nat. Hist. 1888, p. 300) seems to depend upon the idea that the last septum in the young in *Nautilus* and *Ammonites* was always formed at a proportionately increased distance from the penultimate. This supposition is not borne out by specimens of *Nautilus, Witchellia, Lioceras, Ludwigia,* and *Grammoceras* examined by the author.

2. *Shell-muscles of Nautili and Ammonites.*—Two specimens of Ammonites in the author's collection are marked by impressions which seem to indicate the position of the shell-muscle.

2. "On the Drifts of Flamborough Head." By W. G. Lamplugh, Esq., F.G.S.

The author describes in detail the characters and distribution of the glacial deposits on Flamborough Head, and classifies them as follows:—

Alluvial wash, freshwater marls, etc.	Recent.
Late glacial gravels	Glacial.
Upper Boulder Clay	
Intermediate Series. Stratified beds with bands of Boulder Clay	
Basement Boulder Clay	
Chalky rubble	
"Infra-glacial" beds of Sewerby and Speeton.	

He discusses their relationship with other drifts, and arrives at the following conclusions:—

1. The glacial deposits are divisible into Upper and Lower Boulder Clay, with an Intermediate series.

2. The Lower Clay is a continuation of the Basement Clay of Holderness, and is the product of the first general glaciation of the area. The Intermediate series passes laterally into the Purple Clays of Holderness, and has been deposited at the edge of the ice-sheet. The Upper Clay includes the Hessle Clay of Holderness, and marks the latest glaciation of this region.

3. The fossiliferous beds of Sewerby ("Buried-cliff Beds") and Speeton ("Estuarine shell-bed") are older than the Basement Clay, and therefore than the earliest glaciation.

4. The glaciation was effected by land-ice of extraneous origin, which moved coastwise down the North Sea, and did not overflow the greater part of the Yorkshire Wolds.

5. Neither the Boulder Clays nor the Intermediate gravels are of marine origin, the shells which occur in them being derivative.

6. The ice-sheet seems to have filled the North Sea basin in this latitude from the commencement of the glaciation until its close. There is no clear evidence here for a mild interglacial period, but only for extensive fluctuations of the margin of the ice.

3. "On a Phosphatic Chalk with *Belemnitella quadrata* at Taplow." By A. Strahan, Esq., M.A., F.G.S. (Communicated by permission of the Director-General of the Geological Survey.)

Two beds of brown chalk in an old pit near Taplow Court owe their colour to a multitude of brown grains. These grains are almost entirely of organic origin, Foraminifera and shell-prisms forming the bulk of them. Mr. Player has analyzed specimens of the brown chalk, and finds that it contains from 16 to 35 per cent. of phosphate of lime. The tests as well as the contents of the Foraminifera seem to have been phosphatized, the phosphate appearing as a translucent film in the former case, and as an opaque mass in the latter. In the case of the prisms of molluscan shells, the whole of the phosphate appears to be in the opaque form. Minute coprolites also occur, together with many small chips of fish-bone. in which Dr. Hinde has recognized lacunæ, while some have been identified by Mr. E. T. Newton as portions of fish-teeth.

Mr. Player observes that the phosphate occurs in such a condition that it would not improbably serve as a valuable fertilizer, without conversion into superphosphate. This condition is probably due to the partial replacement of carbonate of lime by phosphate in the organisms. The removal of the remaining carbonate leaves the phosphate in a honeycombed state, peculiarly favourable for attack by the acids in the soil.

The author comments upon the resemblance of the deposit to the phosphatic chalk with *Belemnitella quadrata* which is largely worked in Northern France, and upon a less striking resemblance with that of Ciply, which is at a higher horizon.

CORRESPONDENCE.

DYNAMIC METAMORPHISM OF ROCKS.

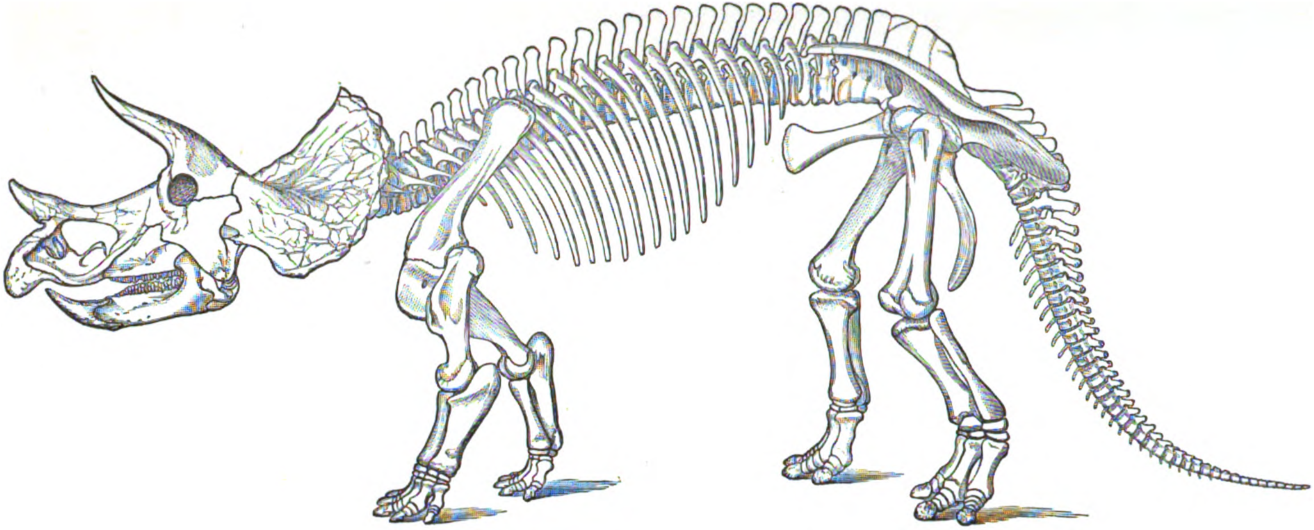
Sir,—It is from no mere love of controversy that I should like just to say, in reply to Mr. Hutchings' query (Geol. Mag. for April, 1891, p. 168), that—while I am unable to appreciate unnecessarily realistic play upon a metaphor which is no invention of mine, and have no right to quarrel with him if he is still smitten with the charms of the fallacy to which I referred—it seems to me that, to apply the term "*dynamic* metamorphism" to a rock whose internal structure shows no signs of *differential* movement (under pressure) of its constituent particles, is only another instance, added to those with which we are already too familiar in petrology, of the abuse of technical language. Further, Mr. Hutchings seems to me to surrender the point in the very next paragraph, if the Coal-seams, by undergoing compression, have acted as buffers to relieve the fire-clays of that portion of the mechanical force which otherwise might be expended upon them to induce a cleavage-structure, in those larger movements, to which the Coal-measures of Northumberland as a whole have been subjected. There seems to be some confusion between *dynamic* agencies of change in the internal morphology of a rock and what Prof. Judd has described as *static* (Geol. Mag. 1889, Dec. III. Vol. VI. pp. 243 *et seq.*), the potency of of which I had previously recognized in my Thesis (see *Chem. and Phys. Studies*, etc., pp. 53–55, 93) to the extent of inducing such metamorphic alteration in chemical compounds previously formed as might complete their individuality *quâ minerals.*

This being so, I may be allowed to repeat my thanks to Mr. Hutchings for his most valuable contributions of *facts*, the full value and bearing of which will perhaps be better seen, when the present acute stage shall have passed of that "pressure on the brain," under which English petrology would seem at present to be suffering.

Wellington College, Berks, A. Irving.
4th April, 1891.

MISCELLANEOUS.

Discovery of Lower Silurian Fishes.—At the meeting of the Biological Society of Washington, on February 7th, 1891, Mr. Chas. D. Walcott, of the United States Geological Survey, announced the discovery of numerous dermal plates apparently of fishes in a formation believed to be of Trenton age, near Cañon City, Colorado. Mr. Walcott contemplates presenting a full account of the subject to the Geological Society of America at their forthcoming meeting in Washington in August next.



Restoration of TRICERATOPS PRORSUS, Marsh (one-fortieth natural size).

A Dinosaur of the Cretaceous period from the Ceratops beds of the Laramie formation; Wyoming Territory, on the Eastern slope of the Rocky Mountains.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VIII.

No. VI.—JUNE, 1891.

ORIGINAL ARTICLES.

I.—The Gigantic Ceratopsidæ, or Horned Dinosaurs, of North America.[1]

(PART II., continued from p. 199.)

By Prof. O. C. Marsh, Ph.D., LL.D., F.G.S., etc.

The Scapular Arch and Fore Limbs.—The scapula is massive, especially below. The shaft is long and narrow, with a thin edge in front, and a thick posterior margin above the glenoid fossa. The distal portion has a median external ridge, and a thick end (Woodcut, p. 242, Fig. 1, *sc.*).

The coracoid is rather small, and in old individuals may become united to the scapula. It is sub-rhombic in outline, and is perforated by a large and well-defined foramen. No indications of a sternum have yet been found in this group (Woodcut, Fig. 1, *cr.*).

The humerus (Fig. 2) is large and robust, and similar in form to that of *Stegosaurus.* It is nearly as long as the femur in one individual, proving that the animal walked on all four feet. The radius and ulna (Fig. 3) are comparatively short and stout, and the latter has a very large olecranon process.

There were five well-developed digits in the manus. The metacarpals are short and stout, with rugose extremities. The distal phalanges are broad and hoof-like, showing that the fore-feet were distinctly ungulate (Woodcut, Figs. 11–16, pp. 245–246).

The Pelvis.—The pelvis in this group is very characteristic, and the three bones, ilium, ischium, and pubis, all take a prominent part in forming the acetabulum. The relative size and position of these are shown in the diagram (Woodcut, Fig. 4), which represents the pelvic elements as nearly in the same plane as their form will allow, while retaining essentially their relative position in life.

The ilium is much elongated, and differs widely from that in any of the known groups of the *Dinosauria.* The portion in front of

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[1] Read before Section C, of the British Association for the Advancement of Science, at the Leeds Meeting, September 4, 1890. See also American Journal of Science (3), vol. xxxvi. p. 477, December, 1888; vol. xxxvii. p. 334, April, 1889; vol. xxxviii. p. 173, August, 1889, p. 501, December, 1889; and vol. xxxix. p. 81, January, 1890, p. 418, May, 1890.

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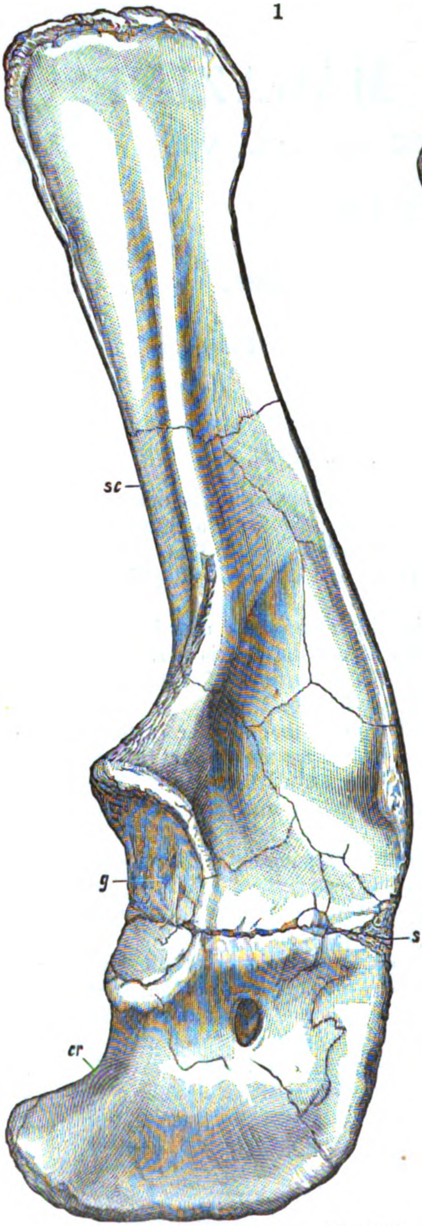

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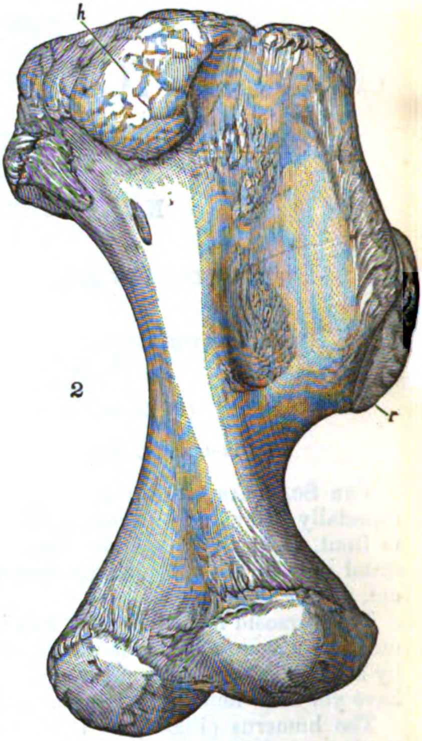

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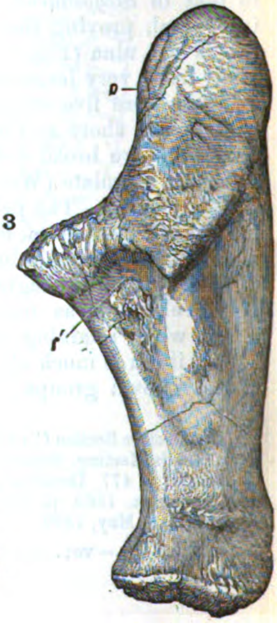
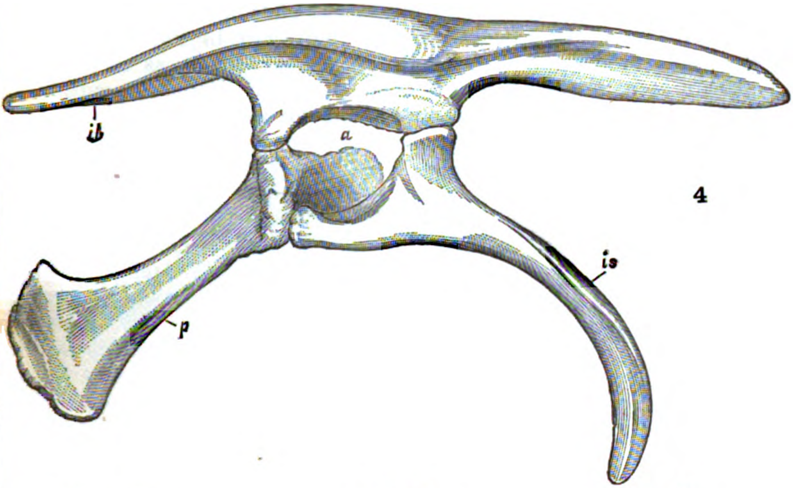


FIG. 1.—Right scapula and coracoid of *Triceratops prorsus*, Marsh; side view.
FIG. 2.—Right humerus of same species; front view.
FIG. 3.—Left ulna of same species; front view. *cr.* coracoid; *g.* glenoid fossa; *h.* head; *o.* olecranon; *r.* radial crest; *r'.* face for radius; *s.* suture; *sc.* scapula. All the figures are one-eighth natural size.



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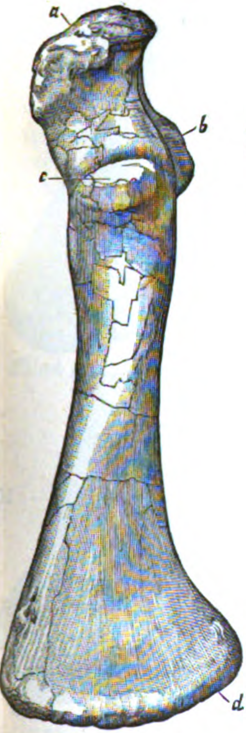

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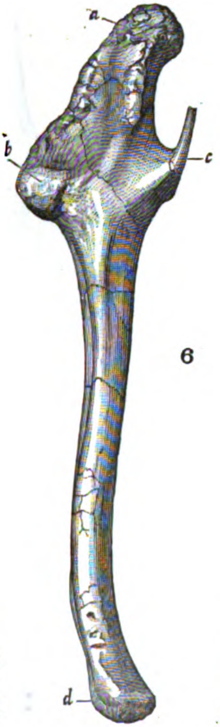

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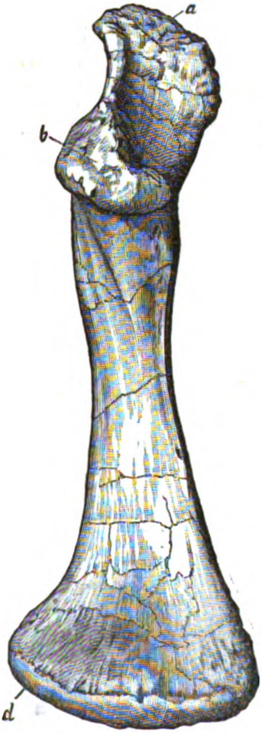

FIG. 4.—Pelvis of *Triceratops flabellatus*, Marsh, side view, one-twelfth nat. size.
a. acetabulum; *il.* ilium; *is.* ischium; *p.* pubis.

FIG. 5.—Pubis of *Triceratops prorsus*, Marsh, side view, one-eighth nat. size.

FIG. 6.—the same pubis; top view. FIG. 7.—The same, side view.
a. proximal end; *b.* face of ilium; *c.* pubic process; *d.* distal end.

the acetabulum forms a broad, horizontal plate, which is continued backward over the acetabulum, and narrowed in the elongated, posterior extension. Seen from above, the ilium, as a whole, appears as a nearly horizontal, sigmoid, plate. From the outside, as shown in the diagram, the edge of this broad plate is seen.

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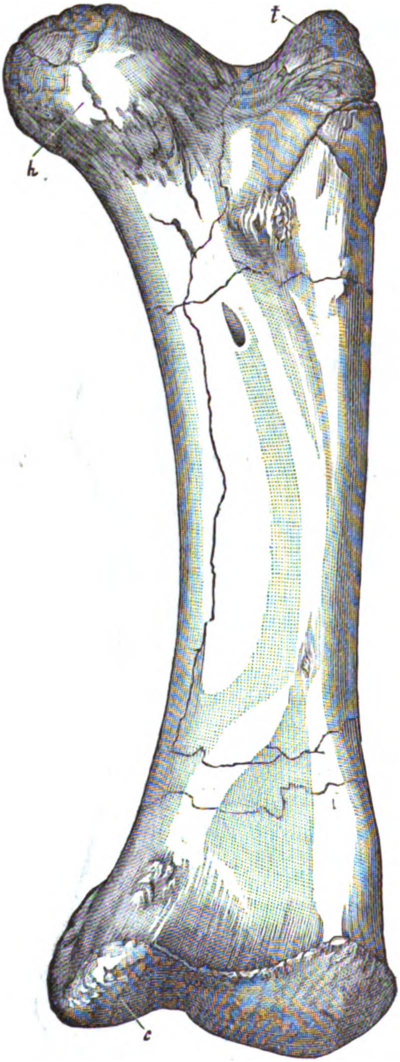

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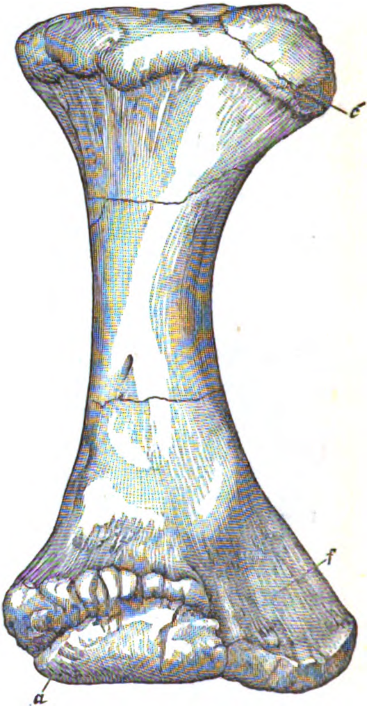

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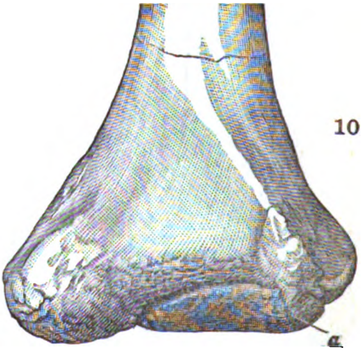

Fig. 8—Left femur of *Triceratops prorsus*, Marsh (front view).
Fig. 9.—Left tibia of same species (front view).
Fig. 10.—The same tibia; distal end; (back view).
a, astragalus; *c*, inner condyle; *c'* cnemial crest; *f*, face for fibula; *h*, head; *t*, great trochanter. Figs. 8—10 all one-eighth nat. size.

The protuberance for the support of the pubis is comparatively small, and elongated. The face for the ischium is much larger, and but little produced. The acetabular face of the ilium is quite narrow.

The pubis is massive, much compressed transversely, with its distal end widely expanded, as shown in the Figure (5). There is no post-pubis. The pubis itself projects forward, outward, and downward. Its union with the ilium is not a strong one, and is similar to that seen in the pubis of *Stegosaurus*.

The ischium is smaller than the pubis, but more elongate. Its shaft is much curved downward and inward, and in this respect it resembles somewhat the corresponding part of the pubis of the Ostrich. There is no indication that the two ischia met closely at their distal ends, and they were probably united only by cartilage.

A comparison of this pelvis with that of *Stegosaurus* shows some points of resemblance, but a wide difference in each of the elements. The pubis corresponds in its essential features to the pre-pubis of *Stegosaurus*, but the post-pubis is wanting.[1]

THE POSTERIOR LIMBS.—The femur (Woodcut, Fig. 8) is short, with the great trochanter (*t.*) well developed. The shaft is comparatively slender, and the distal end much expanded. The third trochanter is wanting, or represented only by a rugosity.

The tibia (Woodcut, Fig. 9) is of moderate length, and resembles that of *Stegosaurus*. The shaft is slender, but the ends are much expanded. The fibula is very slender, and the distal end was closely applied to the front of the tibia (Woodcut, Figs. 9 and 10*f*.). In adult individuals, the astragalus is firmly coössified with the distal end of the tibia, as in *Stegosaurus* (Figs. 9 and 10 *a*, *a*).

The metatarsal bones which were functional are rather long, but massive (Woodcut, Figs. 17–19). Their phalanges are stout, and the distal ones broad and rugose, indicating that the digits were terminated by very strong hoofs (Woodcut, Figs. 20, 21, 22).

All the limb bones and vertebræ in *Triceratops*, and the nearly allied genera, are solid.

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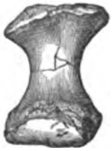

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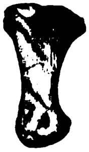

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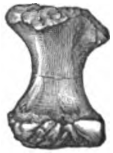

FIG. 11.—Metacarpal of *Triceratops prorsus*, Marsh (front view), one-eighth natural size. FIGS. 12 and 13.—The same bone; side and back views.

THE DERMAL ARMOUR.—Beside the armature of the skull, the body also in the *Ceratopsidæ* was protected. The nature and position of the defensive parts in the different forms cannot yet be

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[1] The pubis recently discovered, and represented in Woodcuts Figs. 5, 6, 7, has a short, splint-like process, which may, perhaps, be a remnant of a post-pubic element, although it has not the position of the post-pubic bone in other Dinosaurs.

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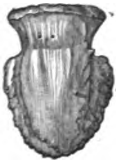

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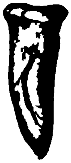

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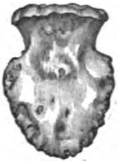

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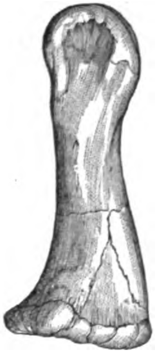

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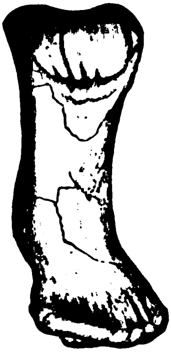

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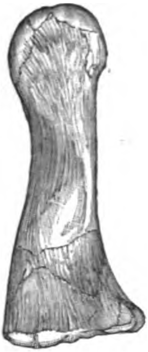

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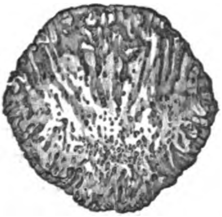

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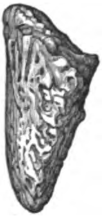

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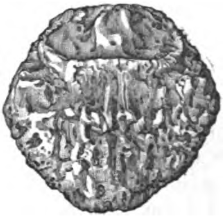

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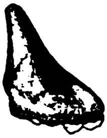

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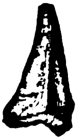

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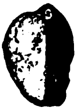

Fig. 14.—Terminal phalanx of manus of *Triceratops flabellatus*, Marsh; front view; one-fourth natural size. **Figs.** 15 and 16.—Side and back views of same.

Fig. 17.—Metatarsal of *Triceratops prorsus*, Marsh; side-view; one-eighth natural size. **Figs.** 18 and 19.—Front and side view of same.

Fig. 20.—Ungual phalanx of *Triceratops horridus*, Marsh; front view; one-fourth natural size. **Fig.** 21.—The same; side view. **Fig.** 22.—The same; posterior view.

Fig. 23.—Dermal spine of *Triceratops*; side view; one-eighth natural size.

Figs. 24 and 25.—Front and top views of same.

Erratum.—In **Geol. Mag.** May No. pp. 195, 196, 197, 199, for *Triceratops* '*porosus*,' read *Triceratops prorsus*, Marsh.—**Edit. Geol. Mag.**

determined with certainty, but various spines, bosses, and plates have been found, that clearly pertain to the dermal covering of *Triceratops*, or nearly allied genera. Several of these ossifications were probably placed on the back, behind the crest of the skull (Woodcut, Figs. 33–34), and some of the smaller ones may have defended the throat, as in *Stegosaurus*.

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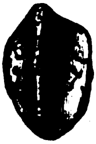

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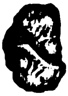

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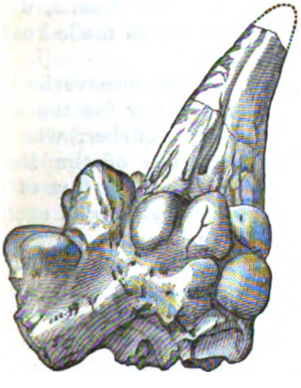

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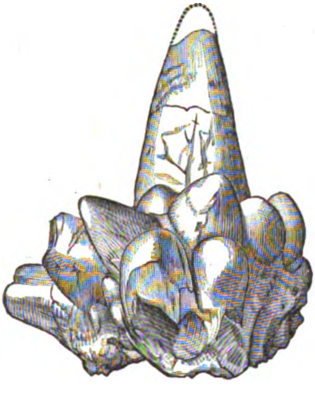

Fig. 26.—Dermal plate of *Triceratops*; top view; one-eighth natural size.
Fig. 27.—Bottom view of same. Figs. 28 and 29.—Side and end views of same.
Figs. 30–32.—Dermal plate of *Triceratops*; top, bottom and side views; one-eighth natural size.
Fig. 33.—Dermal ossification of *Triceratops*; side view; one-half natural size.
Fig. 34.—Front view of same.

The remarkable extinct reptiles here briefly described present many characters which separate them widely from all other known Dinosaurs. Some of these characters are evidently the result of a high degree of specialization, but there are others that cannot be thus explained. The specialization evidently began in the skull, and there reached its greatest development. The peculiar armature of the skull has a partial parallel in the genus *Phrynosoma* among the recent Lizards, and *Meiolania* among the extinct Turtles. A suggestion of the parietal crest may be seen in the existing *Chameleo*, which offers other points of resemblance in its skull and skeleton. These features, however, indicate only a very remote affinity, and it is among the Dinosaurs alone that this group can be placed, as a distinct family, in the order *Ornithopoda*.

The *Ceratopsidæ* resemble, in various points, the *Stegosauria* of the Jurassic, especially in the vertebræ, limbs, and feet. The greatest difference is seen in the skull, but the pelvic arch, also, shows a wide divergence. In the *Ceratopsidæ*, there is no marked enlargement of the spinal cavity in the sacrum, and there is no post-pubis.

The characters above given are based upon fossils which I have personally investigated, including the type specimens of *Ceratops* and *Triceratops*, on which, mainly, the family *Ceratopsidæ* was established. The material now at my command includes the remains of many individuals, among which are portions of about twenty different skulls, and some of these are nearly perfect. In the memoir now in preparation, I shall fully describe and illustrate all the more important of these specimens, and likewise discuss their relations to allied forms.

The generic names, *Agathaumas*, *Cratæomus*, *Monoclonius*, and one or two others, have been given to fragmentary fossils, which may belong to this group, but these remains, so far as made known, appear quite distinct from those here described.

In conclusion, let me say a word as to how the discoveries here recorded have been accomplished. The main credit for the work justly belongs to my able assistant, Mr. J. B. Hatcher, who has done so much to bring to light the ancient life of the Rocky Mountain region. I can only claim to have shared a few of the dangers and hardships with him, but without his skill and energy, little would have been accomplished. If it is borne in mind that two of the skulls weighed nearly two tons each, when partially freed from their matrix, and ready for shipment, in a deep, desert cañon, fifty miles from a railway, you will appreciate one of the mechanical difficulties overcome. When I add that some of the most interesting discoveries were made in the hunting grounds of the hostile Sioux Indians, who regard such explorations with superstitious dread, you will understand another phase of the problem. I might speak of even greater difficulties and dangers, but the results attained repay all past efforts, and I hope at no distant day to have something more of interest to lay before your readers.

II.—APPENDIX.—RESTORATION OF TRICERATOPS.

By Prof. O. C. MARSH, Ph.D., LL.D., F.G.S., etc.

(PLATE VII.)

IN previous numbers of this MAGAZINE, the writer has given the principal characters of the gigantic *Ceratopsidæ*, or horned Dinosaurs, from the Laramie, with figures of the more important parts of the skull and skeleton.[1] The abundant material now available for examination makes it possible to attempt a restoration of one characteristic form, and the result is given in Plate VII. This figure, about one-fortieth of natural size, is reduced from a large outline plate of a memoir on this group, now in preparation by the writer for the United States Geological Survey.

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[1] See GEOL. MAG. 1890, January Number, pp. 1–5, and Plate I. GEOL. MAG. 1891, April Number, Pl. IV. May Number, Pl. V. pp. 193–199, *ante*, pp. 241–248.

This restoration is mainly based on two specimens. One of these is the type of *Triceratops prorsus*, Marsh, in which the skull, lower jaw, and cervical vertebræ are in remarkable preservation. The other specimen, although somewhat larger, is referred to the same species. It consists of parts of the skull, of vertebræ, the pelvic arch, and nearly all the important limb bones. The remaining portions are mostly taken from other remains found in the same horizon and localities, and at present are not to be distinguished specifically from the two specimens above mentioned. The skull as here represented corresponds in scale to the skeleton of the larger individual.

In this restoration, the animal is represented as walking, and the enormous head is in a position adapted to that motion. The massive fore limbs, proportionally the largest in any known Dinosaur, correspond to the head, and indicate slow locomotion on all four feet.

The skull is, of course, without its strong horny covering on the beak, horn-cores, and posterior crest, and hence appears much smaller than in life. The neck seems short, but the first six cervical vertebræ are entirely concealed by the crest of the skull, which in its complete armature would extend over one or two vertebræ more. The posterior dorsals with their double-headed ribs continue back to the sacrum itself, there being no true lumbars, although two vertebræ, apparently once lumbars, are now sacrals, as their transverse processes meet the ilia, and their centra are coössified with the true sacrum. The four original sacral vertebræ have their neural spines fused into a single plate, while the posterior sacrals, once caudals, have separate spines directed backward.

No attempt is made, in this restoration, to represent the dermal armour of the body, although in life the latter was more or less protected. Various spines, bosses, and plates, indicating such dermal armature, have been found with remains of this group, but the exact position of these specimens can, at present, be only a matter of conjecture.

This restoration gives a correct idea of the general proportions of the entire skeleton in the genus *Triceratops*. The size, in life, would be about twenty-five feet in length, and ten feet in height. The genus *Ceratops* so far as at present known is represented by individuals of smaller size, and in some instances, at least, of quite different proportions. A third genus, which may be called *Sterrholophus*, can be readily distinguished from the other two by the parietal crest, which had its entire posterior surface covered with the ligaments and muscles supporting the head. In *Ceratops* and *Ticeratops*, a wide margin of this surface was free, and protected by a thick, horny covering. The type of the new genus is the specimen described and figured by the writer, as *Triceratops flabellatus*, which in future may be known as *Sterrholophus flabellatus*, Marsh. There is some evidence that other forms, quite distinct, left their remains in essentially the same horizon of the Laramie, but their true relation to the above genera cannot be settled without further discoveries.

This group so far as at present investigated is very distinct from all other known Dinosaurs, and whether it should be regarded as a family, *Ceratopsidæ*, as first described by the writer, or as a sub-order, *Ceratopsia*, as later defined by him, will depend upon the interpretation and value of the peculiar characters manifested in its typical forms.

The main characters which separate the group from all other known families of the *Dinosauria* are as follows:

(1) A rostral bone, forming a sharp, cutting beak.
(2) The skull surmounted by massive horn-cores.
(3) The expanded parietal crest, with its marginal armature.
(4) A pineal foramen.
(5) The teeth with two distinct roots.
(6) The anterior cervical vertebræ coössified with each other.
(7) The dorsal vertebræ supporting, on the diapophysis, both the head and tubercle of the rib.
(8) The lumbar vertebræ wanting.

The animals of this group were all herbivorous, and their food was probably the soft succulent vegetation that flourished during the Cretaceous period. The remains here figured are from the Ceratops beds of the Laramie, and were found by Mr. J. B. Hatcher, in Wyoming, on the eastern slope of the Rocky Mountains.

III.—NOTES ON A COLLECTION OF ROCKS FROM THE TONGA ISLANDS.

By ALFRED HARKER, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

THE Tonga or Friendly Islands in the South Pacific Ocean seem to have received hitherto no attention from geologists, and I can find no published information as to their geological constitution beyond the simple record of the existence of volcanoes and coral-reefs. The material of these brief notes was mostly collected by Mr. J. J. Lister, M.A., during the cruise of H.M.S. *Egeria* in 1889; and, through the courtesy of Captain Wharton, R.N., F.R.S., Hydrographer to the Admiralty, I have had the opportunity of examining a few additional specimens collected by Captain C. F. Oldham, R.N., Commander of the *Egeria*, in 1890. In view of the general account of the islands which Mr. Lister is preparing, I notice here only such points as arise directly from an examination of the specimens.

It is well known that most of the Pacific Islands which have been explored seem to be built largely of either volcanic or calcareous formations, usually supposed to be of Recent origin. Indeed the idea seems to have been entertained in some quarters that such was the universal construction of the islands. Drasche,[1] writing in 1879, restricted this theory to those islands lying eastward of a certain line, drawn from Kamschatka through Japan, the Philippines, New Guinea, New Caledonia, New Zealand, Auckland and Macquarie Islands to the Antarctic Victoria. Even at that time, however, such rocks as clay-slates, greywackes, etc., had been recorded in the Chatham Islands[2] and New Britain,[3] east of Drasche's line, and leptinites,[4] granite, and gneiss[5] in the Marquesas, far to the east, Later researches have proved the existence of numerous crystalline rocks, igneous and metamorphic, in the larger islands of the Fiji[6] and Solomon[7] archipelagos, and suggested that in many other islands such rocks may be only masked by a comparatively thin covering of organic or volcanic accumulations.

It may be inquired, then, whether the Tonga Islands show any indication of the existence of denuded crystalline rocks beneath the newer deposits. No such rocks have been found in place, and the evidence available is very slight. Eua, the most southerly of the larger islands, differs to some extent from the rest in geological structure, and from the eastern shore of this island Mr. Lister collected a boulder, one of many there seen, which is neither a volcanic nor an organic rock. I have described it (GEOLOGICAL MAGZINE for April, p. 172) as a uralitised gabbro, and, though some petrologists would prefer to name it diabase, it is unlike any superficially erupted lava. Further, there is no doubt that it is derived from the island on which it was found. The only other suggestive point is the rare presence of minute fragments of red garnet and blue tourmaline in the calcareous andesitic sandstones largely developed in the same island. These fragments, blown out from a volcano, point to the existence of metamorphic rocks below, though at what depth it would be idle to speculate.

With the exception of the dykes mentioned below, the volcanic rocks of Eua seem to consist entirely of fragmental accumulations, no lava-flows being seen. Mr. Lister's collection, however, contains a specimen of a boulder from the same locality as the one mentioned above, which is a grey compact-looking andesite of specific gravity 2·618. It shows under the microscope a kind of flow-brecciation which causes us to compare the rock with extruded lavas rather than with the dykes exposed near the locality in question. The rock [1258] consists of very numerous little plagioclase crystals imbedded, with marked parallel arrangement, in an isotropic ground. The felspars are lath-shaped to acicular, and twinned or simple according to their size. There is little or no augite, but an occasional crystal of rhombic pyroxene transformed into pale green fibrous bastite. Magnetite grains and crystals occur sparingly. The most plentiful secondary product is yellow-green pleochroic epidote, which seems in part to replace some of the larger felspars. The slide shows numerous irregularly shaped patches of andesite differing from their matrix. They are sometimes of finer texture, sometimes coarser, or again have a fine ground enclosing porphyritic felspars. These patches do not share in the general flow structure of the rock, and seem to be relics of a solid crust formed on the surface of a *coulée*, and broken up by subsequent movement of the mass.

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[1] Neu. Jahrb. 1879, p. 265.

[2] See Darwin's "Geological Observations:" cf. Haast, Trans. N.Z. Inst. vol. i. p. 180, 1869, and Hector, *ibid.* vol. ii. p. 183, 1870.

[3] Meinicke, "Inseln des Stillen Oceans," vol. i. p. 133, 1875.

[4] Jardin, Mém. Soc. Imp. Sci. Nat. Cherbourg, vol. iv. p. 55, 1856.

[5] Marcou, "Explic. Carte Géol. de la Terre," p. 185, 1875; authority not cited.

[6] Wichmann, Tsch. Min. Petr. Mitth. vol. v. p. i. 1882.

[7] Guppy, "The Solomon Islands, their Geology," etc., 1887.

Mr. Lister notes three dykes exposed on the eastern shore of Eua. These cut through the volcanic deposits, but are older than the overlying limestones, which they do not penetrate. The specimens are of a dull-grey andesite, sometimes showing porphyritic felspars to about an eighth of an inch long, or little dark spots which represent decomposing pyroxene.

Under the microscope these rocks show innumerable microlites of felspar imbedded in an isotropic base. When porphyritic felspars occur, they exhibit Carlsbad and albite twinning and strong zonary banding in polarized light. Augite is not recognizable in the ground-mass, but occurs in more or less idiomorphic crystals, colourless or nearly so in section, among the earlier minerals. With it is associated a pale yellow enstatite in good prisms terminated by the dome (102) [slide 1261]. Magnetite is present either in crystals of the earlier consolidation or in little granules in the ground-mass. As secondary products we find calcite from the felspars, delessite and calcite from the augite, and green dichroic bastite from the rhombic pyroxene [1260]. A specimen [1259] from the northerly dyke shows the usual microlitic ground traversed by distinct branching veins which consist mainly of larger, though still mostly untwinned, crystals of felspar, extinguishing nearly parallel to their length, and perhaps referable to sanidine. These veins are probably segregations marking the last phase in the consolidation of the mass.

The fragmental volcanic rocks of Eua are well bedded in nearly horizontal strata, and exhibit frequent alternations of types differing in degree of coarseness, etc. Some are of the nature of volcanic dust, forming bands of grey to red colour according to their fresher or more decomposed condition. Among the finely divided material of these bands may be recognized little rounded or irregular bits of brown glassy matter, and broken crystals of clear felspar, green augite, and occasionally pale enstatite. The extinction-angles measured on cleavage-flakes of the felspar show that more than one member of the soda-lime series is represented. The same materials are recognized in various red-brown earthy rocks from the higher ground of the island, apparently formed by atmospheric weathering, and in the fine sand from the beds of the rain-channels in the neighbourhood. The fragments in these fine ash-beds are fairly uniform in size, though occasionally a few small lapilli occur. These deposits are mostly free from carbonate of lime, but there are some which are highly calcareous. Specimens from the northern part of Eua have a white chalky aspect, and effervesce freely with acid, but they contain abundant felspar microlites and broken felspar crystals, some giving nearly straight extinction (oligoclase-andesine?), besides occasional enstatite, etc.

A coarser type of rock, well represented in the collection, may be termed a volcanic sandstone. It resembles an ordinary sandstone of moderately coarse grain, though isolated fragments occur up to about an eighth of an inch in diameter. On the generally yellowish brown surface are seen little scattered broken crystals of black augite and the lustrous cleavage-planes of felspar fragments. Some of the felspar flakes give nearly straight extinction; others are evidently more basic. As before, the bulk of the fragments composing the rock are of brown-stained glassy lava. Good examples come from the mouth of Ana-ahu.

At the last-named locality there is an alternation of harder and softer beds. The softer are of the character just described; the harder differ from them in possessing a cement of calcite, which forms a large part of the rock. These calcareous beds, which occur also in other parts of the volcanic series of Eua, present under the microscope some points of interest. One of these features, the occasional presence of minute chips of characteristic metamorphic minerals, has already been alluded to. Slices [1268, 1273] show that the fragments, some of which appear rolled, are of brown-stained andesite, enclosing many felspar microlites and occasionally a porphyritic crystal. The larger pieces have the spongy character of pumice. Besides the andesitic fragments, are seen little chips of minerals such as might be derived from the same source; clear plagioclase, pseudomorphs of calcite after felspar, and brightly polarising pyroxene; also rarely a grain or two of quartz, seemingly clastic. The matrix of crystalline calcite encloses numerous foraminiferal tests which seem to belong for the most part to Globigerina. More rarely occurs a small chip of shell or a fragment recalling the characteristic structure of an echinoderm plate. The calcareous matrix further exhibits in parts a beautiful oolitic structure, giving the black cross well defined in polarised light. The structure is of the spherulitic type, with radial but not concentric arrangement, and is quite different from the rolled oolitic grains well known in our Carboniferous and Jurassic limestones. It is produced *in situ* by molecular action, as is sufficiently proved by the fact that one of these spherulitic growths occupies each chamber of the foraminiferal tests.

It seems clear that the whole of these volcanic rocks of Eua are of submarine origin. This appears from their uniform and horizontal stratification, the indications of the "sorting" action of water, and the occurrence at various horizons of highly calcareous rocks, some containing marine organisms. Probably some parts of the deposits come from the destruction of volcanic accumulations thrown up above sea-level, such as Falcon Island at the present day, which is being rapidly destroyed by the waves.

The volcanic rocks of Eua are overlain, with evident unconformity, by massive white limestones, and the earlier group must have suffered considerable denudation before the newer was deposited. This appears from the fact that while the horizontally bedded volcanics crop out in the interior at a height of more than a thousand feet, the limestones come down to sea-level on the coast within a distance of half a mile. Further, the dykes which cut through the volcanic deposits terminate without entering the overlying calcareous strata.

The limestones occur in three terraces, and Mr. Lister was led to regard them as elevated reefs. He observed reef-corals on the edge of the lower terrace and on the top of the highest one. An examination of a few thin sections of the rocks showed indeed a comparative want of coral fragments, the rocks sliced, with their abundant foraminifera, some of large size, recalling strongly the Orbitoidal Limestones of Sumatra and Borneo as described by Messrs. H. B. Brady[1] and A. V. Jennings[2] respectively. When good coral remains occur, they are associated with similar foraminifera, etc. [1329]. The specimens have, however, been submitted to Dr. John Murray, whose large experience of calcareous deposits is well known, and, pending the results of his examination, it will be sufficient here to notice the more obvious petrological characters of the rocks.

Some examples, *e.g.* from Maui's Oven, are rough-textured yellowish limestones, in which abundant foraminifera can be seen on a hand-specimen. In general, however, the deposition of secondary calcite has converted the mass into a white or cream-coloured limestone of very compact appearance, not unlike some travertines, but containing sometimes little irregular vacuities which the calcite cement has not filled.

The specimens sliced, whether from the lower, the middle, or the upper terrace, show abundant foraminiferal tests and other organic remains which will not be more closely described in this place. Small oolitic growths are common in the secondary calcite cement, but they are invariably of the spherulitic type. Concentric-coated oolitic grains are conspicuously absent, nor is there any trace of clastic material such as quartz- or shell-sand, volcanic detritus, etc. The only large fossil observed is a cast of a *Cerithium*, not perfect enough for specific determination.

I pass on to the specimens from other islands composed partly or wholly of volcanic accumulations. The purely coral islands, Tongatabu, Vavau, Nomuka, etc., will not be noticed.

Mango (Comango on the Chart) appears to be built entirely of volcanic ejectamenta. Mr. Lister found no lavas except as fragments in the tuffs. These, in the specimens examined, range up to about six inches in length, and have a dull brown decomposed aspect, with in many cases small vesicles filled with calcite. A slice of one [1267] shows a microlitic andesite with marked flow-structure and much ferruginous decomposition-product. The rock is not porphyritic.

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[1] Geol. Mag. (2), Vol. II. p. 532, 1875.

[2] Geol. Mag. (3), Vol. V. p. 529, 1888.

The fragmental accumulations from this island vary much in character. Specimens from the eastern hill are white chalky-looking rocks, in which nothing is to be seen beyond a rare crystal of augite. They are very calcareous, and the residue after treatment with acid is merely a mass of very fine scoriaceous and dusty material with fragments of crystals of felspar, hypersthene (?), apatite, etc. From other parts of the island come fine grey ashes with white spots of decomposing felspar. These are non-calcareous, and consist of minute fragments of brown-stained glass and various volcanic minerals mingled with fine dust. Other rocks unmixed with calcareous matter are, rather, volcanic sandstones, enclosing numerous fragments, usually rounded, of yellow or brown lava, etc. Specimens of coarser texture—volcanic conglomerates—come from the western or Observation Hill. These have a partly calcareous matrix and include fragments of lava usually an inch or more in diameter and of subangular form. In these coarse accumulations occur blocks of coral, specimens of which are as much as six inches across, and have portions of the conglomeratic rock adhering firmly to them.

Nomuka-iki is a small island lying to the south-west of Nomuka. It is described as consisting in its northern part of a flat of coral sand, while the southern and higher portion is of stratified volcanic ashes, alternately fine and coarse, which are well exposed in a cliff on the west, and contain marine fossils. The specimens from here are mostly yellow-brown or greyish ashes of fine texture, only occasionally showing fragments up to an eighth of an inch long, some of which are of decomposing andesite. Little glistening felspars are visible with a lens, besides countless little black dots which seem to be partly altered pyroxene. Some specimens from the upper layers are rather coarser, and show more conspicuous fragments. In these, well-formed prisms of lustrous black augite may be recognized as well as the felspars. The microscope shows that these latter are, as usual, of a triclinic species; that a green, pleochroic rhombic pyroxene occurs, in addition to the green augite; and that yellowish volcanic glass and fine dust are also represented. None of the Nomuka-iki specimens are calcareous enough to effervesce with acid. The only fossil in the collection is a well-preserved *Pyrula.* It rather resembles the Eocene *P. nexilis,* but has more delicate markings, and is perhaps to be matched among later forms.

Tonumeia, a small island situated to the south of Nomuka and Mango, consists, according to Captain Oldham's observations, of stratified volcanic tuffs, which are exhibited in a cliff 80 feet high on the west coast, showing a dip of 3° to the south. A specimen (I.) of the finer tuff is a rather fine volcanic ash compacted by a calcareous and ferruginous cement into a dirty yellow-brown rock. In the residue insoluble in dilute acid are recognized chips of a monoclinic and a fibrous rhombic pyroxene with a basic felspar, besides the usual brown-stained glassy and scoriaceous fragments.

Other specimens from this island are pebbles found on the beach. One (II.) is a coarsely amygdaloidal lava, perhaps not a native rock. Two others are black nodules of irregular but rounded form, the larger being two inches in diameter (III.). They have externally a graphitic lustre, while the interior is duller and shows a certain eccentric radial structure. Rough chemical tests indicate some oxide of manganese, and the general characters are those of psilomelane; but the interior is softer, and the specific gravity of one nodule was found to be only 3·54. This perhaps indicates a partial conversion into wad or some other hydrated substance. These nodules are evidently native to the island, and portions of the calcareous matrix in which they have been imbedded are still adherent on their surfaces.

Captain Oldham also collected specimens from the small island Tonua (not named on the Chart) situated north-east of Mango. Of these, an "altered coral sand" (IV.) from the summit of the island seems to be free from foreign admixture; the rest, from a cliff 20 feet high on the north side, are volcanic ashes usually with but little calcareous matter, despite the fact that organic remains are visible in several specimens. These stratified volcanic rocks, with an easterly dip, build the mass of the island. Most of the specimens are soft yellow-white rocks with a lumpy appearance, although the enclosed fragments, up to about an inch in diameter, do not differ essentially from the matrix in which they are imbedded (V. and V*a*.). Minute glistening crystals of felspar and augite are visible here and there in the dull mass, and the microscope shows only these minerals with an occasional broken needle of apatite, and much fine dusty matter. In other examples from the same cliff the fragments are more distinct, and many of the smaller ones are rolled bits of dark lava (VI. and VII.). These rocks contain numerous organic remains, among which the most conspicuous seem to be the conical tests of Pteropods: a rather indistinct cast of a Gasteropod also occurs—possibly a *Murex* from the form of its canal, although the varices are not very strongly marked. One specimen is traversed by a half-inch seam of fine, non-calcareous character, with a dark grey colour, clearly indicating the stratified nature of the deposits. The microscope shows the usual triclinic felspars and green pyroxene, the felspar crystals and fragments being especially abundant, together with fine volcanic dust and glass fragments. There are also very slender needles of a highly refracting yellow-brown mineral, which has much of the appearance of rutile—a mineral scarcely to be expected in such a connexion.

Falcon Island came into existence owing to a volcanic eruption which occurred in the year 1885.[1] The main mass of the island consists of a fine grey ash, mostly quite incoherent, but containing crumbling lumps. The microscope shows this to be a volcanic dust similar to that so widely dispersed during the eruption of Krakatau. It is composed largely of comminuted crystals, among which are recognized felspars, some with twin-lamellation, green augite, and

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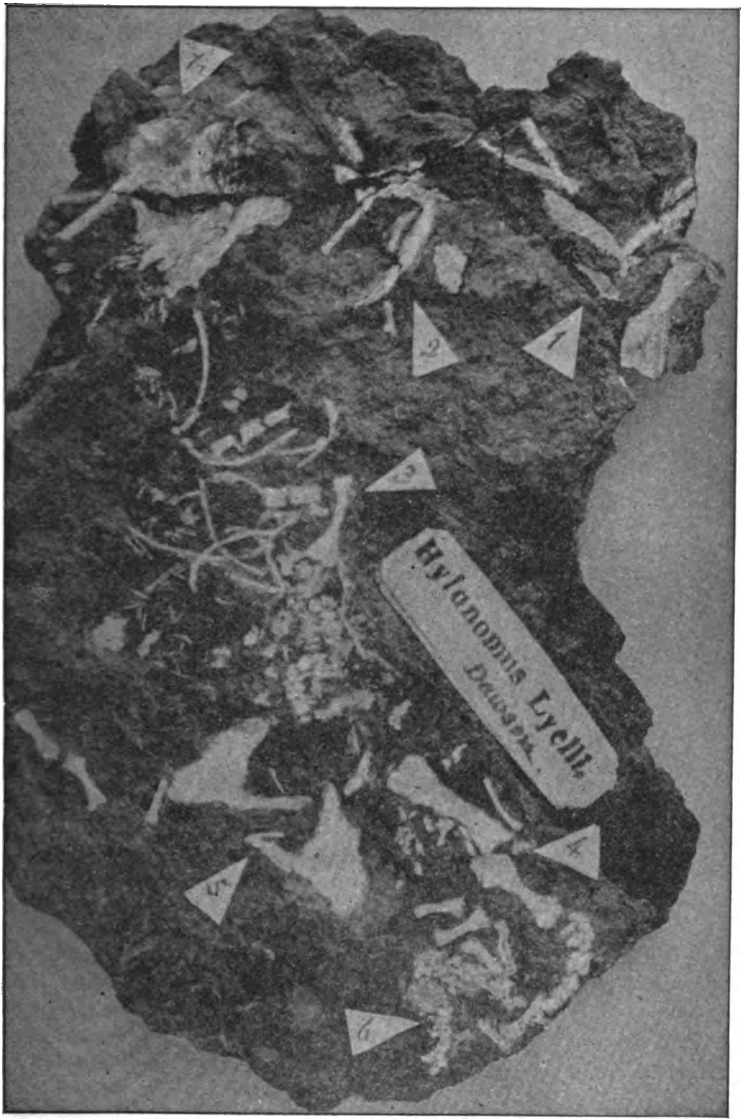
[1] A Visit to the newly emerged Falcon Island, Tonga Group, S. Pacific, by J. J. Lister, Proceedings of the Royal Geographical Society, March, 1890.



Remains of Hylonomus Lyelli, Dawson, 1859.

Coal-Measures, South Joggins; Nova Scotia.

(1) Cranial bones and mandibles; (1a) Sternal and shoulder bones; (2) Mandible; (3) Humerus, ribs and vertebræ; (4) Hind limb; (5) Pelvis; (6) Caudal vertebræ.

a rather fibrous rhombic pyroxene. Some of the felspars are andesine, but they are not all of one variety. With these minerals occur many fragments of yellowish glass, often with very irregular shape and concave boundaries, such as would arise from the breaking up of pumice.

The coarser accumulations would rather be termed agglomerates. They have a rough and often porous texture, and are largely composed of bomb-like ejectamenta, a quarter or half an inch in diameter, besides pieces of vesicular and pumiceous lava. The interspaces are often partly vacant, with a dusty lining. These agglomeratic rocks are grey or yellowish, but become red or brown by weathering.

Mr. Lister's collection from Falcon Island includes a number of specimens from the ejected blocks of lava scattered over the island. These are more or less vesicular rocks, showing numerous little glassy felspars, one-tenth to one-fifth of an inch long, imbedded in a dark grey ground. Some, perhaps rather weathered, show a lighter grey; while others, more glassy, are black with a silky lustre. The vesicles usually vary from mere pores to cavities an inch or more in length; but in some examples they are drawn out into narrow pipes more than six inches long. The more scoriaceous and cellular varieties are free from porphyritic crystals, and the perfectly glassy pumice is pure white.

These lavas appear to be basic augite-andesites, neither olivine nor rhombic pyroxene being detected. One of the sliced specimens gave a specific gravity 2·436, but this is evidently too low, and indeed the specimen contains numerous microscopic vacuities; a more compact example gave 2·708, which seems to indicate a decidedly basic composition.

In the slices [1264–1266] the porphyritic felspars seem, from their extinction-angles, to be bytownite. They have Carlsbad and albite-twinning, and some of the larger ones show pericline-lamellæ in addition. The crystals are well bounded, but often grouped in clusters so as to interfere with their perfect development. The crystals are clear, but contain glass-cavities, usually with zonal disposition, and some entangled portions of the ground-mass. The augite, pale yellow in section, is not very abundant. Some of the larger crystals are so associated with the porphyritic felspars as to prove that they belong to an early phase of consolidation, but the bulk of the mineral occurs in ill-shaped idiomorphic crystals scattered through the ground. The ground-mass consists of numerous lath-shaped microlites of felspar imbedded with a more or less fluxional arrangement in an isotropic glass. The proportion of glassy base varies considerably, as might be inferred from the appearance in hand-specimens. A very characteristic feature is the occurrence in the mass of well-defined irregular, or usually round, patches of lighter colour and containing less isotropic base than the surrounding mass. These seem to be portions of lava which while partly consolidated became involved in a more fluid magma [1264].

With the exception of the Falcon Island rocks, all those examined from the Tonga Islands appear to be of submarine formation. The absence or presence in different strata of any sensible proportion of calcareous matter and organic remains is perhaps related to the more or less rapid rate of accumulation at different epochs of eruption. The volcanic material ejected seems to have been almost exclusively of fragmental character, and in some cases there are indications of violent explosive action. This is quite in accord with the andesitic nature of the materials thrown out, which are of types common in the Pacific region. As to the age of the rocks it would be idle to speak until the evidence of their organic contents has been duly set forth, but it would undoubtedly be very rash to refer them all to a Recent age, and some of them may be found to go back far into Tertiary times.

IV.—NOTE ON *HYLONOMUS LYELLI*, WITH PHOTOGRAPHIC REPRODUCTION OF SKELETON.

By Sir J. WILLIAM DAWSON, F.R.S., etc.

(PLATE VIII.)

AS a sequel to my recent paper on new specimens of *Dendrerpeton*, I have thought it desirable to reproduce by photogravure, for comparison, the type specimen of *Hylonomus Lyelli* now in the collection of the Geological Society of London. The reproduction (Plate VIII.) is of the natural size, though less distinct than in the original. Though the bones are scattered, this specimen enabled me, by measuring the separate bones and adding the cuticular scales found on other specimens, to restore the animal in my "Airbreathers of the Coal Period."[1]

The specimen represented is one of the largest found. Most of the others represent smaller (probably in some cases half-grown) specimens, though not showing any structural differences. It will be noticed that the caudal vertebræ are seen in this example, a fact which I had forgotten when the former paper was written. In the species of *Hylerpeton* and *Fritschia*, though the teeth are different, the development of the limb-bones seems to have been similar. In *Smilerpeton occidentatum* the limbs would seem to have been shorter than in the case of other forms in the erect trees, and the skull long and narrow.

The specimen here delineated, though the bones are scattered, has the advantage of lying on a flat plane of lamination. Some of the thinner bones have, however, scaled off, or have been removed by aqueous infiltration. The cavities left by these have been touched with white so as to bring them out. The difficulty in restoring most of the specimens in the erect trees arises not from the absence of the bones, but from these being scattered through non-laminated material, sometimes soft and crumbling, in other cases hard and arenaceous. In either case it is a work of time and care to uncover the bones, and many of these cannot be reached without risking the destruction of others. Some material of this kind representing *Fritschia*, *Hylerpeton*, etc., is still only in process of development, and may perhaps yet enable their skeletons to be reproduced more perfectly than heretofore.

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[1] Also on a larger scale in "The Chain of Life in Geological Time."

REFERENCE TO PLATE VIII.

(1) Skull and Maxillæ; (1*a*) Sternal and Scapular bones; (2) Mandible; (3) Humerus, Ribs and Vertebræ; (4) Hind Limb; (5) Pelvis; (6) Caudal Vertebræ.

V.—NOTE ON THE ALLEGED GENESIS OF RUTILE IN FIRECLAYS.

By Major-General C. A. MACMAHON, F.G.S.

MR. W. M. HUTCHINGS' "Notes on the Fireclays of the Coal-measures," published in the April Number of the GEOL. MAG., contains many interesting facts and suggestions on which I should like to offer a few remarks.

The conclusion at which the author appears to have arrived (see para. 2, p. 168, read with the two bottom paras. of that page) is that the formation of the "rutiliferous mica," and its contained rutile, is due to dynamo-metamorphism.

This is rather a startling conclusion and it is one which seems to rest on slender evidence. Even if it could be proved that the rutiliferous mica and the free rutile-needles are both of secondary origin, no evidence has been adduced to show that their genesis is due to dynamic and not to ordinary aqueous agencies. Evidence on this point is the more desirable as one does not usually associate beds of unindurated clay with the display of dynamic energy. Do fossils of these Coal-measures exhibit pressure deformation?

Even in cases where sedimentary rocks have evidently suffered deformation from earth-movements, it would not be safe to assume, without proof, that the secondary minerals found in them owe their birth to dynamic causes.

With respect to the Seaton beds there are two distinct issues to be proved. Are the rutile-needles and the yellow mica of secondary or of clastic origin? And if secondary, to what process do they owe their birth?

Regarding the first issue I remark that some of the author's facts seem quite consistent with the view that the rutiliferous mica, and the free rutile-nodules, were transported to the spot along with the other constituents of the clay. The finest washings "A, B, C," contain "far away the largest portion of the rutile-needles;" and many of the quartz and felspar grains carry "more or less a skin of rutiliferous 'paste' in spite of all the washing and agitation. I think it is," Mr. Hutchings adds, "really corroded on to the substance of the grains in many cases." These facts do not give much support to the theory that the mica and its endogenous rutile "is a new formation posterior to sedimentation."

Another fact mentioned by the author seems to point to the same conclusion: he tells us that the flakes of rutiliferous mica, with few exceptions, are seen by their extinctions to be "aggregates of more or less numerous smaller flakes overlapping one another, and with different optical orientation." If, as I understand, the orientation is promiscuous, this fact seems to point to the deposition of the flakes one above the other by water—ordinary sedimentation—rather than to crystallization *in sitû*. As the molecules of crystals possess strong polarity, the molecules of mica would, at the moment of crystallization, surely have followed the laws of crystallization and have arranged themselves in definite order either as simple or as twinned crystals. If, on the other hand, these "complex flakes" are the mere promiscuous agglomerations of numerous separate individuals, and not single crystals, I fail to see how the fact of this agglomeration supports the contention that the "rutiliferous mica" is a secondary mineral formed after the deposit of the clay. Finely divided fragments of mica suspended in water would be very likely to come together as mechanically mixed agglomerates even before they sank to the bottom. This process, I suspect, is probably responsible for Mr. Hutchings' "globular aggregates in which the mica lies in all azimuths." The attraction which minute particles suspended in water exercise on each other may be observed in a chemist's test-tube every day.

The author in his examination of the mud prepared in the Laboratory from the fireclay observed an upward and a downward limit in the size of the flakes of rutiliferous mica, and he attaches considerable importance to the fact. "Looking at the facts stated," he writes at p. 167, "the one that appears to have most bearing on the main point concerned is the pretty strict upward limit of size of the rutiliferous flakes." Mr. Hutchings' contention is that the genesis of the rutiliferous mica, and the rutile contained in it, is due to dynamo-metamorphism "posterior to sedimentation" (p. 168), and as the fact stated above seems to be "the main point concerned," it is worth while to consider it in some detail.

In the first place I would ask whether we can be quite sure that the fact relied on is not in some way due to the process of "fractional levigation" employed. Mr. Hutchings' process involved the crushing of dried clay to powder and subsequent crushing in a mortar with water, followed by repeated washings. After such dynamic treatment, I doubt the value of any theory, as to the origin of the rutile, based on the size of the mica flakes that were finally found to contain rutile compared with the size of the flakes in which this mineral was absent. Free rutile flakes appear to be more abundant (p. 165, para. 2) than those included in mica; and the author tells us, at p. 166, that "the rutile lies mainly in between the minute component flakelets, and is set free when these are detached." And as Mr. Hutchings' contention is that the rutiliferous mica is a secondary product formed subsequent to the deposition of the clay, it follows logically that the free rutile-needles were detached from the mica in Mr. Hutchings' laboratory under the gentle persuasion of his pestle and mortar.

Considering the rough treatment the mica received in the laboratory or during its previous transport by river, and considering the fact that the bulk of the rutile-needles (p. 165) were free and detached from mica flakes, it does not seem remarkable to me that the larger flakes should have been landed on the stage of the author's microscope minus their rutile-needles. The flakes of rutiliferous mica appear to have been below $\frac{1}{1000}$th of an inch in diameter, and owing to their extreme microscopic size may have been protected from abrasion by their superior powers of flotation.

If mica, as Mr. Hutchings seems to think, was the mother of the rutile, we can hardly suppose that *all* the mica transported to the Seaton beds was sufficiently rich in titanic acid to furnish the titanium dioxide for the rutile. The titaniferous mica was probably only one of several species of mica transported to Seaton; and if so, each species may have been characterized by a size of flake peculiar to itself. But apart from the question of habit, differences in the size of the flakes may have resulted from another cause. Mr. Hutchings found three species in his fireclay; muscovite, biotite, and a yellow to green species containing rutile-needles. No evidence has been adduced to show that all three species came from the same parent rock. They may, therefore, have come from different areas, and the differences observed in the size of the flakes may be the measure of the distances travelled by the different species.

The circumstance that rutile-needles were not found in the muscovite or in the biotite may be owing to the fact that these micas do not contain sufficient titanium dioxide; and I fail to see what bearing the absence of rutile from the muscovite and biotite has on the points at issue, viz. whether the rutile and the yellow mica are of clastic or secondary origin, and if secondary, whether their genesis is due to ordinary aqueous or to dynamic agencies.

If, for sake of argument, we admit that the rutile is of secondary origin, can we be sure that any of the species of mica found in the fireclay was the mother of the rutile? Without disputing Roth's conclusion that the "separation of the titanic acid of weathered micas as rutile is often enough observed," it seems desirable to call attention to the fact stated by Mr. Hutchings that "micaceous ilmenite" is "rather abundant" in his fireclay. May not this mineral have supplied the titanic acid for the rutile? The fact that some of the needles of rutile are found between the mica "flakelets" does not negative this suggestion, because capillary action is a potent factor in such cases. There is no evidence in Mr. Hutchings' paper to show that any of the mica of the fireclay contains titanic acid, whereas we know that ilmenite contains a large amount—sometimes as much as 59 per cent.—of titanium dioxide.

Lastly, I would suggest that if the yellow species of mica and the rutile are really secondary minerals, they are products of ordinary aqueous action. I think it will probably be admitted that the fireclay of the Coal-measures was laid down in water. If so, the soft mud of which it was originally composed must have contained much interstitial water. What has become of this water? May we not assume that much of it was used up in chemical action on the finely triturated minerals of which the solid portion of the mud was composed? The water, unless it differed from all other river and sea-water of which we have knowledge, must have contained free oxygen, carbonic acid, and other potent chemical reagents. Are we to believe that these active reagents sat still and did nothing for thousands upon thousands of years until at the end of æons dynamic metamorphism, like a muscular pedagogue with a long birch, came to warm them into action?

VI.—POST-PLIOCENE CONTINENTAL SUBSIDENCE (IN AMERICA) *versus* GLACIAL DAMS.

By J. W. SPENCER, M.A., Ph.D., F.G.S. L. and A.

THE growing interest in the evolution of the Continent now calls for more accurate information than formerly regarding the changes of level of land and sea in recent geological times. The amount of these oscillations was one of the most important factors in the investigation of the "Building of the Great Lakes." Hence the study of the history of the lakes has contributed to our knowledge of the changing relations of the continent and the sea.

From a study of the submerged channels along the American coast, it has been shown that the continent was greatly elevated during some epoch or epochs intervening between the middle Miocene and the early Pleistocene periods.[1] The elevation of the land was over three thousand feet higher than now, and probably reached for a short time to over five thousand feet.

The elevated condition of the continent was followed by a depression of the land to far below the present altitude, before the upward movement restored the now existing conditions. There may have been more than one episode of elevation and depression; but the problem that we seek to answer is: What was the maximum depression of the later Pleistocene times, after the great beds of boulder clay were formed? for the great elevation was shortly before that epoch.

Most geologists are ready to accept the high continental elevation, but there are differences of opinion respecting the amount of the subsidence. Although many have their own views upon this subject, few serious attempts have been made to solve the problem unbiassed by theory.

We must seek for the evidence of the late regional elevation in the remains of old shore-lines, such as beaches, terraces and sea-cliffs, which are more or less disturbed and obliterated. Isolated remnants of beaches are not accepted by all as proof of a recent elevation, although found at high altitudes, but the beaches often contain the direct proof of their own elevation.

No better example is found than the Iroquois Beach of the Ontario Basin. This elevated shore-line is one of the youngest and best preserved in the Great Lake region. It rests upon the youngest "till" deposits. Since its formation it has been warped towards the north-east, and thus at Fine, north of the Adirondack Mountains, it has been lifted over 600 feet above its own elevation at the head of Lake Ontario.[1] By another series of deformed shore-lines,[2] it has been found that the Iroquois Beach at the head of the lake has been lifted its own height above the sea. Hence there is measured proof that the northern side of the Adirondacks has been recently elevated a thousand feet, or that it was recently a thousand feet lower than now. The initial point of this movement was near the head of Lake Michigan. Its maximum deformation occurs in the Adirondacks, and amounts to six feet per mile. Whether this rise continues to the Atlantic, or is transformed into a depression, or is faulted east of the mountains, remains a question to be determined. Only fragments need be looked for east of the region already explored, for the deserted shore has been traced into a region of broken mountains and wilderness.

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[1] "High Continental Elevation preceding the Pleistocene Period (in America)," by J. W. Spencer, GEOL. MAG. Decade III. Vol. VII. 1890, p. 208.

Three hundred feet above the Iroquois plain the Algonquin Beach of the Huron basins is located.[3] In it there is a similar deformation to that recorded in the Iroquois shore, but the initial point of the warping is beyond the head of Lake Michigan. With the deformation continuing to the north-east, it would appear that the Laurentian Mountains north of the Great Lakes were very much depressed during the Algonquin episode. The evidence of the formation of the Algonquin Beach at sea-level has already been collected.[4]

Whilst there is great deformation recorded in the higher beaches, the surveys of these more broken geological records do not enable us to trace the shore-lines down to sea-level, as in the case of the Iroquois, and to nearly as perfect an extent, the Algonquin Beach. Consequently, it is necessary to rely more fully upon the perfection of the structure of the deserted shores, and upon their positions, which would preclude their formation in confined lakes. Such conditions exist in Ontario, Michigan, and Ohio, where extensive surveys have been made.

The lower of these shores, as the Ridgeway Beach,[5] like those before named, were formed about bodies of water which opened only to the north or east. But ascending a little higher, the Maumee Beach[6] occurs at altitudes which permitted its formation in water having free communication with the Ohio and Mississippi valleys by two depressions. Above this plain there are higher gravel terraces and plains in Michigan, and elsewhere, notably those between Kalamazoo and Marshall, with an elevation of a little more than 900 feet above the sea. From them the country falls away by steps towards the lakes; but the sheet of water which they once bounded had at least five connexions with the drainage of the Mississippi system.[1] Other higher terraces about more insular points are found in the same region, and farther north in Michigan they are said to occur at the summit of the highest land east of Grand Traverse Bay at 1682 feet above tide.

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[1] "The Deformation of Iroquois Beach and Birth of Lake Ontario," by J. W. Spencer, Amer. Journ. Sci. vol. xl. 1880, pp. 443–451.

[2] *Ibid.* p. 447.

[3] "Deformation of the Algonquin Beach and Birth of Lake Huron," by J. W. Spencer, Amer. Journ. Sci. vol. xli. 1891, pp. 12–21.

[4] *Ibid.* p. 21.

[5] "High Level Shores in the Region of the Great Lakes and their Deformation," by J. W. Spencer, Amer. Journ. Sci. vol. xli. 1891.

[6] *Ibid.*

In Ontario there are well-marked sea-cliffs carved out of the Niagara escarpment, as westward of Collingwood, especially at elevations of from 1200 to 1425 feet above the sea. At various intervals, between the plain of the Algonquin Beach and the highest land of the peninsula—1709 feet—there are also terrace and beach deposits moulded out of the drift. These remnants of shores are seen to within 20 feet of the highest point of land. The shore-markings of these elevated lands are rendered more certain by the perfectly water-worn stones, and the extent of the beach and terrace structure. The sea-cliffs are too deeply graven to represent evanescent coast-lines. But all of these records are interrupted owing to the topography of the country, erosion by atmospheric agencies, and the recent Pleistocene deformation of the region.

Some of the positions of the surveyed coast-lines have been mapped; for a detailed list of localities reference should be made to "High Level Shores in the Region of the Great Lakes, and their Deformation."

Again, at Dog Lake, north of Lake Superior, Professor H. Y. Hind observed terraces at 1425 feet above the sea.[2]

After allowing for all the measurable Pleistocene and recent deformation of the region, these elevated shores stand out so high above every natural barrier, even far away to the south as well as to the north, that their occurrence demands explanation by other than local causes.

The highlands of the Ontario peninsula do not form Nilometers reaching more than 1700 feet above the sea; but in Potter County, Western Pennsylvania, 100 miles south of Lake Ontario, they develope a watershed reaching to 2680 feet above tide, with the Genesee river flowing north to Lake Ontario; the Alleghany to the Ohio river; and Pine Creek to the Susquehanna. About the highest flattened knob, of only a few acres in extent, and rising to within twenty feet of its summit, there is a ridge of small, well water-worn gravel, nearly free from sand. Mr. Carvell Lewis speaks of it as kame-like,[3] but its structure and form is not different from that which may be true beach. This is emphasized by the occurrence of a zone of boulders forming a pavement a few feet below the gravel ridge—a feature so commonly developed in front of the deserted beaches of the Lake region. This gravel ridge rests upon the highest point of land at the very front of the "terminal moraine" of Mr. Lewis, with the land declining to the north, as well as falling away to the south. These gravels form a superior deposit resting upon "till" charged with angular shingle of local

[1] Cited before.

[2] "Assiniboine and Saskatchewan Expedition," 1859, p. 120.

[3] "A Terminal Moraine," by H. C. Lewis, Geol. Survey Pennsylvania, Rept. Z, p. 143.

Carboniferous sandstones, and it is out of this material that the pebbles were formed.

There are similar superficial gravels on other, but, of course, inferior knobs along the very foremost portions of the "terminal moraine." But the drainage from these ridges is to the north, and Mr. Lewis emphasized the fact that there is no drift in the small streams flowing to the south. The theoretical importance of this observation will be noted later.

Besides these highest of all the superficial gravels, south of the Great Lakes, which I have examined, I have also visited the high terraces of the Genesee River flowing northward from the deposits just described. Here several pauses in the receding waters are recorded. These are notable from an elevation of 1900 feet downward. At this named high altitude the valley is nearly a mile wide, and now 250 feet below the terrace. Our knowledge of these elevated and disconnected water deposits is yet very scanty, but certainly very suggestive, when supplementing the surveys of the lower coast-markings in the lake region.

A very interesting terrace remains in a valley three or four miles to the east of Horseheads, New York. The altitude of the terrace is 1200 feet above tide, whilst the gravel-covered floor of the valley, at Horseheads, is only 900 feet. This last valley is over a mile wide, and is that connecting the trough of Seneca Lake with the Susquehanna Valley.

Similar elevated terraces have been noted by Prof. I. C. White along the higher Potomac Valley facing the Atlantic, and along the adjacent tributaries of the Monagahela, which drains to the westward. These deposits he notes up to an elevation of 1675 feet above the sea, and 175 feet above the valley, along a tributary creek above St. George, W. Va.[1]

At Nachvak, in Labrador, Dr. Robert Bell found beaches of great distinctness at 1500 feet above the sea. Gravel and shingle terraces were also found to an estimated height of 2000 feet.[2]

It has already been noted that the differential rise of the Iroquois Beach, north of the Adirondack Mountains, amounts to six feet per mile, and that it has there been lifted to a thousand feet. If this rise continue to the White Mountains, then the equivalent of the Iroquois Beach may be found amongst the terraces of the high valleys in that region. Its records may be preserved still further north-east, on the drift-covered sides of Mount Katahdin, in Maine. Mount Desert, on the coast of Maine, rises to 1500 feet,[3] and shows remnants of coast action to its summit (Shaler); consequently, it is too low to bear records of the Iroquois shore, unless the warping at the earth's crust becomes one of depression east of the Adirondacks.

In Ontario, some of the high shores, referred to above, occur at elevations of a thousand feet above the Iroquois plain; therefore their equivalents in the northern Adirondacks should be looked for at about 2000 feet above tide. The beaches reported in Vermont by Prof. Hitchcock,[1] at or below 2300 feet, doubtless correspond to some high shore-lines of the Ontario peninsula. Upon the same basis, these high beaches should be looked for at 3000 feet in the White Mountains, and at greater elevation on Mount Katahdin, in Maine.

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[1] "Rounded Boulders at High Altitudes," by I. C. White, Amer. Journ. Sc. vol. xxxviii. 1887.

[2] Rept. Geol. Surv. Canada, 1885, DD, p. 8, and Bull. Geol. Soc. Amer. vol. i. p. 308.

[3] "Geol. Mount Desert," by N. S. Shaler, Rept. United States Geol. Survey, 1888, p. 993.

If we regard the gravels of the highlands of Pennsylvania as having been formed at sea-level, then it would be reasonable to look for their counterpart at elevations of over 4000 feet on Mount Washington, in New Hampshire, and to the summit of the drift (4400 feet) on Mount Katahdin. These conjectural estimates, based upon a possible uniformity, may aid in the correlation of the topographic features of the mountain region of the east and of the lake region.

As far as relates to the north-eastern portion of the continent, our observations on Neptunian phenomena have now been epitomized. An explanation is necessary. That the pebbles of the beaches and the shore-lines were the results of wave or current action no one questions, but there are differences of opinion as to the conditions under which the waters moulded their coast-lines. Were these deserted shores constructed at sea-level, or were they moulded in glacial lakes? These are the theoretical questions before us.

The difficulties which the sea-level theory present to some minds may be stated to be—(*a*) a great regional depression of the continent; (*b*) the absence of absolute continuity of the beaches; (*c*) the absence of marine organisms in the beaches; and (*d*) the personal equation of theoretical views. On the other hand, the theory of glacial dams presents such obstacles that their value will be considered at length.

The idea of the hydrostatic stability of the continent must not be too strongly relied upon, for the evidence adduced, showing that the continent lately stood three, or even temporarily at six thousand feet higher than now, appears conclusive. Such mobility of the earth's crust being established, there appears no reason why the terrestrial pendulum could not have moved equally in the opposite direction, and carried down the highlands of Pennsylvania to nearly three thousand feet, or those of New England to twice this depth. The objections to such subsidence could only be based upon its magnitude, which observations must settle.

The absence of the continuity of the shore-markings is an objection only to a limited extent. Part of the reported absence arises from the imperfections in the explorations, owing to their changing character; the local non-formation of beaches, as described in a previous paper;[2] the failure of identification of separated points, owing to subsequent terrestrial deformation; and the interruptions occasioned by topographic features and subsequent obliteration by erosion. All of these difficulties are greatest in the higher regions, for there the beaches must be looked for amongst islands and detached mountain knobs.

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[1] Geology of Vermont.

[2] "Ancient Shores, Boulder Pavements, and High-level Gravel Deposits in the Region of the Great Lakes," by J. W. Spencer, Bull. Geol. Soc. Amer. vol. li. 1889, pp. 77.

The absence of marine remains seems perhaps the greatest obstacle to the acceptance of a sea-level formation of the beaches, as marine organisms are found only up to 520 feet.[1] But the Pleistocene gravels occur in Georgia and Alabama, in positions facing the sea, at altitudes of 700 or 800 feet, and higher up the greater valleys at 1500 feet,[2] without their containing any marine remains. Even where marine Pleistocene beaches occur on the coast of Norway, there are very few localities where shells are found. How many of the older geological formations are unfossiliferous? How many of those ancient beach deposits now represented by conglomerates, porous sandstones, and, indeed, many clays, are entirely barren? Under such conditions have we a right to pronounce judgment on the freshness of waters based on the absence of aqueous organic remains? This question will be referred to again in considering the glacial dam theory.

As to the personal equation, it ought not to pass beyond the limit of conservatism into the province of obstruction: but it is quite proper that it should be considered; for, as Prof. Geikie has said, when controversy ceases, the interest in the investigation declines.

Glacial lakes are of two kinds, those whose waters are retained by morainic barriers, and others sustained by ice barriers alone.

The former class is represented in several valleys in the Alps, where lateral glaciers enter and cross greater valleys; sometimes the glacier carries its lateral moraine across the valley, and builds a more or less permanent earth dam. Such lakes remain long after the glacier has melted away, and, even when drained, show evidence of their origin. A consideration of this class of glacial lakes does not enter into the subject of this paper.

In Switzerland, Greenland, and Alaska, other glacial dams are now well known. These are retained by the ice alone. When glaciers, free from morainic materials, descend lateral valleys, and cross other valleys, they do not obstruct the river, for it continues to flow beneath the ice. However, there are many places where glacial lakes occur between the ice and the sides of the valleys; especially is this the case where two glaciers meet at the end of a mountain spur, like Lac Taoul in Switzerland. Small glacial lakes sometimes occur where lateral valleys unite with the glacial-filled channel, like the Marjelen See. All modern glacial lakes are of small size. One of the largest lakes described in Greenland is not over three or four miles long, and a mile wide.[3]

Such lakes, when they exist above sea-level, are evanescent. Mr. H. Topham described some glacial lakes of Alaska which discharge by a tunnel eight miles long, under 500 feet of ice.[4] Mr. I. C.

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[1] At Montreal.

[2] On the Upper Etowah River of Georgia.

[3] Medelelser om Groenland.

[4] Proc. Roy. Geogr. Soc. 1888, p. 424.

Russel makes similar reports. The out-flowing waters enlarge the tunnels, thereby draining lakes; but the ice-roofs fall in, and by the accumulation of ice blocks the tunnel becomes temporarily obstructed, causing the water of the lakes to rise. In the very nature of the case, large lakes could not be expected, for the conditions which would permit their formation would cause the glaciers to recede. Especially would this be the case if the glaciers were hundreds of feet above the sea, with rivers draining beneath or through them. It would be difficult to perceive how any water-level could be maintained long enough to permit the waves to carve out terraces and sea-cliffs. With glaciers coming down into the sea, it is easy to understand how bays and inlets could be obstructed by the ice so as to allow the water to be freshened. In such lakes the water-level would be maintained long enough to leave inscriptions in the form of terraces and beaches.

Such is a brief account of the natural history of glacial dams. It has been said that the easiest explanation of the theory of our great lakes is by regarding them as formerly great glacial dams. So it was thought ten years ago, that the least troublesome hypothesis of the origin of the great lake basins was by their excavation by glaciers; but the writer, going into a field of investigation, almost sealed by pre-judgment, has shown that glaciers did not scoop out the basins, and has otherwise found satisfactory explanation of their origin,[1] without invoking the necessity of ice being converted into rock diggers. So also the evidence of glacial dams has not been found as far as my observations have been extended.

Let us examine how the glacial dam theory applies to the shore-lines already described.

The physical features of the Ontario basin are the most favourable for the construction of a great lake retained by glacial dams. As proved by its deformation, the Iroquois beach was formed at sea-level. If this proof of the altitude of its birthplace did not exist, the evidence of its elevation would be obtained from a consideration of the ability of glaciers to close the St. Lawrence valley to the north-east. Such a barrier would have been from 80 to 100 miles wide, and from 800 to 1300 feet deep (below surface of water) according to location. Yet the drainage of the then expanded lake, over 300 miles long (as far as surveyed) and 100 miles or more in width, was against, into, or under the supposed glaciers, except to a limited extent in its earliest stages, when a partial overflow was by the Mohawk Valley. Had the lake been above sea-level, a river as large as the St. Lawrence would soon have eaten its way through the ice, and lowered the lake, for in that direction alone it had to flow; consequently, the great out terraces and beaches requiring centuries or millenniums of time, could not have been formed except at sea-level.

If the Algonquin Beach of the Upper Lakes were formed in a glacial lake, then the ice barrier in the region of Lake Nipissing would have been 600 or 700 feet beneath the surface of the water. The drainage must have been under the ice, and have amounted to a discharge equal to that of the modern Detroit River, as the drainage of Lake Superior, Lake Michigan, and Lake Huron basins would have been thus borne seaward, descending 300 feet to the level of the Iroquois water. Under such conditions, the question may be asked, how could the lake surface be retained long enough at any level to carve out the deeply-graven water-lines and terrace-plains of the Algonquin Beach, in place of the discharging waters melting away the icy barriers, which were supposed to have been the means of retaining the lake 300 feet above the level of the Iroquois waters?

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[1] "Origin of the Basin of the Great Lakes of America," by J. W. Spencer, Quart. Journ. Geol. Soc. Lond. vol. xlvi. p. 523.

We now rise to the shores which bounded the Warren water. These have been explored from Lake Michigan to New York, and to north-east of Toronto, upon the Ontario peninsula. Upon the glacial dam theory, this sheet of water would need a barrier to the north as well as to the east. The drainage of the lake, at all stages from the Ridgeway Beach downward, was to the north-east, and beneath a greater mass of ice than in the case of the Algonquin or the Iroquois water. But above the Ridgeway Beach,[1] at the Maumee level,[2] there were outlets across Ohio and Illinois, if it were a lake. The difficulties are increasing.

The shore markings occurring near Kalamazoo, at about 900 feet above tide, represent a sheet of water having at least five outlets across Ohio and Illinois.

Again, the sea-cliffs of the Ontario peninsula, at from 1200 to 1425 feet and more, and the beaches now found up to 1689 feet, would demand great dams to the south as well as to the north. But such dams could scarcely have existed, with open waters carving out sea-cliffs and terraces on the high peninsula of Ontario, and also leaving records, 200 miles to the south. It should be noted that gravel deposits of the so-called *kame* and *ösar* structures occur at all high levels, but of these I do not take cognizance.

The drainage of this high country, such as the Genesee valley, with terraces up to 1900 feet or more, and of the "terminal moraine" up to 2680 feet, was toward the north without obstruction.

Ascending now to Potter County, we find the gravel ridge at 2660 feet, on the very edge of the highest knob of the "terminal moraine." This high point could not have stood out of the ice as a Greenland *Nunatak*, with a lake around it, for it is at the margin of the drift, and glaciers do not deposit their terminal detritus within the ice, but at their very margins. It seems impossible to conceive a glacial mass retaining a lake about this flattened knob, even if the country were submerged to almost sea-level.

There are other similar deposits on adjacent summits. Again, had a glacier existed on the top, or on the southern side of this "moraine" ridge, its melting ice must have carried great quantities of drift into the valleys to the south, which neither Mr. Lewis nor

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[1] "High Level Shores in the Region of the Great Lakes and their Deformation," by J. W. Spencer, Amer. Journ. Sci. vol. xli. 1891.

[2] *Ibid.*

I have seen. But the drainage was to the north, into the hypothetical glacier, which, if it permitted subglacial drainage, could scarcely have formed lakes.

Under these conditions fairly stated, I think, whether is it easier to accept a great subsidence of the continent to nearly 2700 feet, in Western Pennsylvania, or account for the phenomena by glacial dams, formed on land, vastly lower to the north.

Indeed, the great deformation of the lake region had scarcely begun, and consequently even the modern highlands, north of the great lakes, were then very much lower than now, when compared with the region to the south. I cannot hesitate in forming a conclusion that the evidence is in favour of a late continental subsidence, rather than of hypothetical glacial lakes, hundreds of miles long and broad, like nothing ever seen, which could not answer the requirements.

The difficulty in accepting the subsidence without the occurrence of marine shells has in part been pointed out. But their absence in the lower beaches may be accounted for, in part, by the sheets of water being more or less cut off from the sea, and receiving great quantities of fresh water. This, however, will not explain their absence on the higher beaches. The varying climatic conditions of the water, and the changes of level, destroying the life, and too rapid to allow of remigration, may in part account for the absence of organisms in the shore-lines.

The record of subsidence deciphered in the high shore-lines of the lake region is supported by the observations of Dr. G. M. Dawson, Mr. R. G. McConnell, and others, on the mountains rising above the great plains of North-Western Canada, and on the mountains between there and the Pacific Coast. Dr. Dawson[1] finds gravel terraces upon high sides of the Rocky Mountains facing the east, in position showing their origin not to have been river-terraces.

From extensive observations Dr. Dawson concludes that the Pleistocene submergences amounted to 4000 or 5000 feet in the region of the International Boundary (49th parallel), whilst in Alaska it did not exceed 2500 or 3000 feet. He also hypothecates two episodes of submergence, the latter being less extensive than the former. Further, he regards the elevation and subsidence of the great plains and western mountains as alternating, and that the drift materials of the plains were deposited at sea-level.

Mr. R. G. McConnell informs us that on Cypress Hills, with an altitude of 4800 feet, the drift does not rise above 4400 feet. A hundred and fifty miles to the north-west the drift is not found above 3400 feet on Hand Hills (Tyrrell). But south of the Cypress Hills, near the 47th parallel, drift occurs up to 4660 feet on Three Buttes (Dawson). From these figures Mr. McConnell shows a differential level of 7·2 feet per mile, the elevation being greater nearer the 49th parallel.[2]

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[1] "Later Physiographical Geology of the Rocky Mountain Region in Canada, with Special Reference to Changes in the Elevation and the History of the Glacial Period," Trans. Roy. Soc. Canada, 1890.

[2] Geological Survey of Canada, Report for 1885.

In the east, the history of the changes has not been fully deciphered. Erratics occur on the top of Mount Washington to 6300 feet, whilst on the top of Mount Katahdin, in Maine, they occur to only 4400 feet (Upham). Conforming with Dr. Dawson's views, as applied to the west, we have a greater rise in the White Mountains than eastward. The altitude of beach formation in the highlands of Labrador (1500 to 2000 feet) shows the recent uplift to have been less than in New England.

Combining the movements of the east and the west, it would appear that the great Pleistocene uplift reached its maximum along a line between the Gulf of the St. Lawrence and Vancouver Island, rather than in higher latitudes. The youthfulness of the northern topographic features shows that the elevation of the lands in the higher latitudes, above the base-level of river-erosion, has taken place in recent geological times; for there is a lack of such great cañons in the country to the north of the great lake zone, as occur in the region to the south of it.

If the subsidence of the northern portion of the continent appears to have been great, that of Barbadoes to the south-east appears to have been greater, for Messrs. J. B. Harrington and A. J. Jukes-Browne,[1] have pointed out that there are on the island oceanic deposits resting upon beds of sandstones and shales of probable Miocene age, and beneath coral formations of age not greater than the Pleistocene. These deposits indicate an origin of not less than a thousand fathoms, and, as Mr. Jukes-Browne points out, probably of vastly greater depth. This geologically recent subsidence was likely to have been synchronous with that of the north, but may have been one of those alternating conditions hypothecated by Dr. Dawson.

The fjords of the coast of Norway show that the Scandinavian peninsula stood 4000 feet higher than now. The silts and terrace deposits at 3000[2] feet point to a subsidence of that region, the same as similar deposits in the mountains of America.

The deep submerged channels south of Asia, like that of the Ganges, which is 3570[3] feet deep, point to a recent submergence to that amount. But such deep channels are not known in the north of Asia, consequently the higher latitudes do not show a great amount of recent depression. The Pliocene deposits of Sicily, at 3000 feet, demonstrate a recent elevation.

Pliocene deposits in the south-east of England are now found at 600 feet above tide. Their counterparts at Utrecht have been shown by Mr. Clement Reid to be now submerged more than 1143 feet.[4]

The oft-quoted Moel Tryfaen deposits, in north-western Wales, contain marine shells at 1400 feet, with similar but unfossiliferous beds rising to nearly 2000 feet. These deposits, which I have visited, I consider to have been formed where found. But they do not represent so late a subsidence as our deposits in the lake region, for they are not the superficial gravel, but are covered by a few feet of more recent till.

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[1] Geology of Barbadoes, 1890.

[2] "High-Level Terraces of Norway," by J. R. Dakyns, GEOL. MAG. 1877, p. 72.

[3] Brit. Admiralty Chart, No. 70.

[4] "Nature," August 12, 1886, p. 342.

These few foreign examples, just cited, show that the continental movements, as set forth in this paper, are not peculiar to America, but they were probably not synchronous, although they have taken place in the most recent geological times.

This paper must of necessity be imperfect, as it is the first attempt to work out the detailed evidence of recent terrestrial subsidence from records in the ancient shore-lines, many of which have only lately been reported. All of the phenomena cited show that in modern geological times there have been gigantic movements causing the earth's crust to move to and fro, producing conditions which have greatly modified the physical features, climatic conditions, and distribution of life.

VII.—THE EFFECT OF SEDIMENTATION ON THE TEMPERATURE OF THE EARTH'S CRUST.

By T. MELLARD READE, C.E., F.G.S., etc.

MY letter in the March Number of the GEOLOGICAL MAGAZINE, asking for a description of the "Herschel-Babbage" theory of Mountain formation, appears to have called forth Mr. Davison's "Note on the Expansion Theory of Mountain Evolution,"[1] in which he favours us with his definition of the "fundamental principle of the theory of terrestrial evolution which has sometimes been called the 'expansion theory.'"

Whether this fundamental conception is identical with the "Herschel-Babbage" theory is not stated, but I am obliged to Mr. Davison for putting his views on the subject into a form admitting of examination and discussion. To make my meaning plain, I shall have to repeat Mr. Davison's own words.

"Masses of sediment laid down in an area of subsidence are gradually lowered to regions of the earth's crust that are at a higher temperature than that in which they were deposited. The sediment, being heated, expands, is crumpled and folded internally, and, bulging up at the surface, is reduced by denudation to the form of a mountain-chain."[2] On which the following observations are made. "It is obvious that the heat which passes into and expands the sediment must be withdrawn from the immediately adjoining parts of the earth's crust, partly laterally, but chiefly from below; and that the amount of heat gained by the sediment must be equal to that lost by the crust."

So far from this being "obvious," I consider it a fundamental misconception. If a mass of strata at the surface having the surface temperature could be placed in contact with another mass, say ten miles deep, having the temperature due to that depth, the colder rock would withdraw part of the heat from the hotter till an equality of temperature was reached. But this is not what takes place; the subsiding rock does not come into contact with strata at a higher temperature.

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[1] GEOLOGICAL MAGAZINE, May, 1891, p. 210.

[2] It is unnecessary for me to criticize this "fundamental" definition further than to disclaim it as an adequate statement of my own theory. For an outline of this I must refer those interested to the forthcoming June number of the Philosophical Magazine.

So far from heat being withdrawn laterally and from below, the general outflow of heat is checked in the areas where sediments are being laid down. In these areas the sphere is losing *less* heat than where the surface continues in a normal condition. A portion of the heat that would otherwise escape into space is being used up in heating the sediment.

Mr. Davison seems to have had a glimmering of this truth before completing his "Note," for the last paragraph but one is entirely opposite and contradictory to the preceding which I have quoted.

Unfortunately the effect has not been to compel him to withdraw the erroneous view, but to attempt to minimize the dynamical effect of the true one. Having dealt pretty freely with the quantitative problems in my "Origin of Mountain Ranges," I do not propose to enter upon this phase here.

To say that the sediment piled up in an earth trough "*withdraws*" heat from the underlying strata is about as correct as to maintain that covering a steam-boiler with felt withdraws heat from it. To give an illustration; if the valley of the Dead Sea were levelled up with sediment, the underlying rocks would be raised to a temperature dependent upon the thickness of the sediment and its coefficient of conductivity. The raising of the temperature of a body is not usually considered to indicate a withdrawal of its heat.

VIII.—ON THE PREPARATION OF A CHEAP HEAVY LIQUID, FOR THE SEPARATION OF MINERALS.

By W. B. D. EDWARDS, A.R.C.S.,
of the Geological Survey of India.

THE high price of all heavy liquids, and the consequent care that has to be taken in using them, the latter of course entailing great expenditure of time, were the reasons which caused me to make experiments, with regard to the manufacture of Klein's solution (borotungstate of cadmium) on a small scale. The price quoted in a well-known chemical manufacturer's price-list is 3*s.* 6*d.* per oz. My experiments have shown me that it can be made for about 7*d.* per oz., plus the value of the time of the maker. The process is very simple, and not much time is necessary in making it. A rough outline of the method of preparation is given by Dr. Klein in the Comptes Rendus, vol. xciii. August, 1881.

The apparatus required consists of two large porcelain evaporating dishes 10′ diameter, two of 6′, and two of 3′, two glass beakers 10′ deep, and two 6′ deep, a glass funnel and a water bath. A fume cupboard or some arrangement for carrying off acid fumes is also necessary. The following weights given will make 160 grains of cadmium borotungstate (*i.e.* about 50 c.c.), and can be conveniently manipulated in vessels of the size given above.

Dissolve 450 grams of crystallized sodium tungstate in as little boiling water as possible. When quite dissolved, add 675 grams of boric acid in small crystals, a little at a time, and with constant stirring. This should be done in a large beaker.

When quite dissolved, the solution should be poured into a large evaporating dish and put aside in a place where it will not be disturbed or shaken. It should be covered up from dust. In about twenty-four hours, or longer, the liquid, which is of a light purple colour, should be poured off quickly into another evaporating basin from the crystals. The latter should be in the form of a hard solid deposit at the bottom of the basin. These crystals can be washed with hot water three or four times, the washings being added to the mother-liquor.

The latter will now probably be found to be in a thick pasty condition, due to the formation of small crystals. These will be found to dissolve up on heating the dish and its contents on a water bath. About half of the water can now be driven off on the water bath, care being taken not to drive off so much that a crust begins to form on the surface of the hot liquid. The solution is again set aside as before and left to cool and crystallize. The liquid is poured off into one of the smaller dishes and the crystals washed as before. This process of crystallization is gone through again until a piece of orthoclase will float in the liquid. The principal point being to always make the polyborates of soda crystallize out either as single large crystals or as a hard crystalline crust. It is impossible to separate and wash the crystals if they are very small.

Owing to the high density of the liquid, in the later stages a longer time is necessary for the sodium borates to crystallize out than at first. A piece of glass or felspar will be found to float when the liquid has been evaporated down to about 220 c.c. The next process is to heat the sodium borotungstate on the water bath to 100° C.; pour into a large beaker, and add a boiling saturated solution of barium chloride. This should be done carefully, stirring the solution while pouring the $BaCl_2$ in, a little at a time. The $BaCl_2$ solution should consist of 150 grams of crystallized $BaCl_2$ in about 200 c.c. of distilled water. A dense white precipitate forms on pouring the barium chloride solution into the sodium borotungstate, and this precipitate should be stirred for some minutes so as to thoroughly mix the two liquids. After a few minutes hot water should be added and the precipitate stirred up thoroughly. In a short time the supernatant liquid can be siphoned off from the precipitate. This washing process should be repeated some 10 or 15 times. The white precipitate is next transferred to a large evaporating dish, and about 300 c.c. of dilute HCl added (1 HCl to 10 H_2O); the mixture of precipitate and solution is evaporated to dryness on a water bath, about 40 c.c. of strong HCl being added towards the end.

The dried mass is then treated with about 300 c.c. of hot distilled water, the former being thoroughly broken up into fine powder with a glass rod flattened at one end.

The green sediment of tungstic hydrate is filtered off and washed, the washings being added to the solution of barium borotungstate. The liquid is evaporated down and allowed to stand. Yellow crystals are formed, and with a little care these can and should be obtained as single large crystals. The latter crystallize in two forms, one as modified tetragonal prisms with well-developed basal planes, and the other as flattened forms much resembling hexagonal forms in shape.

Nearly the whole of the barium borotungstate can be obtained, the mother-liquid being evaporated down a little more after each crop of crystals has been obtained. Towards the end of the process transparent colourless platey crystals of barium borate may separate out as well. The barium borotungstate crystals should be dissolved up in water and recrystallized once again. They should then be dissolved up in about 200 c.c. of distilled water and a solution of $Cl\,So_4$ added from a burette or a pipette, care being taken to add it very slowly, drop by drop as long as a precipitate falls, and the precipitate of $Ba\,So_4$ is then filtered off and the filtrate is evaporated down in a porcelain dish on a water bath till a piece of olivine floats on the surface. This liquid will be found to have a specific gravity of 3·46 at 60° F., and it takes some hours before some of the salt crystallizes out and the specific gravity falls to 3·28. It might thus perhaps be used for the separation of some minerals of specific gravity greater than 3·46, though care would have to be taken not to allow crystals to form on the lighter minerals and thus sink them.

It will be found that the cost of the chemicals used will come to about three shillings, viz.:—

450 grams (nearly 1lb.) sodium tungstate	1*s.*
675 ,, (nearly 1½lb.) boric acid	9*d.*
150 ,, (5¼ ounces) barium chloride	4½*d.*
25 ,, (0·87 ounces) cadmium sulphate ...	6*d.*
Pure hydrochloric acid, filter papers, etc.	4½*d.*

The quantity of cadmium borotungstate obtained is about 160 grams, or 50 c.c. The borotungstate crystals separate out from the solution saturated when hot and are nearly colourless.

The crystals of barium borotungstate obtained earlier in the process cannot be mistaken when once seen. They are light yellow, transparent, and have a splendid lustre. The surface becomes yellow and opaque on washing with water.

The principal difficulty in the manufacture of this liquid is the care that has to be taken in crystallizing the various salts out from their solutions. There is no reason why any geologist with a little knowledge of chemical manipulation should not make his own heavy liquid, or why the manufacturer should charge such an exorbitant price as at present, as the actual time spent in making it is very small, though spread over several days.

In conclusion, I must express my obligations to Prof. Judd, F.R.S., who has afforded me great facilities in carrying out these operations.

REVIEWS.

I.—An Introduction to the Study of Petrology: the Igneous Rocks. By Frederick H. Hatch, Ph.D., F.G.S. pp. 128. (London, Swan Sonnenschein & Co. 1891.)

THE object of this little book (as stated in the preface) is to describe the mineral constituents and structure of the Igneous Rocks, their mode of occurrence and origin; and the author has fulfilled his task in an accurate, clear, and concise manner.

Petrology is rapidly developing a language of its own, and Dr. Hatch, who has already done good service in explaining the meaning of its many terms in his Glossary (appended to Teall's British Petrography), gives also many useful definitions in his present work. It will be of service, therefore, as a text-book for students who are giving especial attention to Igneous rocks, while to geologists in general it will be a handy book of reference on the principal Igneous rocks, and their distribution in the British Islands. These portions of the subject occupy about one-half of the volume, the other half being mainly devoted to the constituent minerals. We may observe, by the way, that a few diagrams showing the mode of occurrence of the rocks would have been useful.

The title of the book is, perhaps, a little misleading (unless the work be intended to form one of a series), for the author has brought us into the presence of Petrology, without giving us any real introduction. The student will find that he cannot make acquaintance with the subject without a good preliminary knowledge of Optics and Crystallography, to say nothing of Chemistry. Dr. Hatch, it is true, states that the scope of his work is too small to admit the treatment of Optical phenomena, and he refers the student to the lately published and excellent "Notes on a New Form of Polarizing Microscope," by Allan B. Dick. Mr. Dick's "beginner" is told how to measure angles of extinction, and how to observe the "dispersion," and the character of the pleochroism of any mineral, but even he must start with some preliminary training, and Mr. Dick recommends Spottiswoode on Polarized Light.

Thus the student who wishes to master the methods of research, and be enabled to undertake investigations on his own account, must seek help elsewhere. He will find much practical information in Rutley's "Rock-Forming Minerals," but that work is not altogether free from technical terms, that may be familiar to the advanced student, but which might discourage the beginner. Prof. Cole's "Aids in Practical Geology" introduce the subject in a far simpler form, and thus provide more easy lessons on Petrology and its methods of research. Dr. Hatch's book contains only the main facts concerning Igneous rocks, and it will not educate the student to identify his specimens.

Although the identification of Igneous rocks is a task that now-a-days requires much special training, Petrologists unfortunately appear to attach but little importance to rock names. They prefer to treat the rocks as mineral aggregates and to describe their structure and composition. The field-geologist is mainly concerned with their mode of occurrence and origin; and to him rock-names are a necessity. We are glad to find that the needs of the field-geologist are not neglected by Dr. Hatch. Referring to the classification of the rocks, he says "Chemical composition (as far as the percentage of silica is concerned) and mode of origin or occurrence occupy a chief place. Mineralogical composition is, on account of its extreme variability, allowed to play only a subsidary *rôle.*" In this difficult task of furnishing a classification of the Igneous rocks, Dr. Hatch has achieved success.

II.—DR. H. FILHOL ON THE FOSSIL MAMMALS OF SANSAN.

ÉTUDES SUR LES MAMMIFÈRES FOSSILES DE SANSAN. Ann. Sci. Géol. vol. xxi. Art. 1; pp. 320, 46 plates.

THE small village of Sansan, near Auch, in the department of Gers, has long been celebrated for the number of remains of Mammals found in beds belonging to the *Miocène Moyen* of the French geologists, and also for the beautiful state of preservation in which many of these remains occur. The first in the field to undertake the description of these specimens was the late M. Edouard Lartet, but his investigations appear to have been hampered by the lack of sufficient opportunities for illustrating his descriptions with figures. This want was to a certain extent remedied by the late M. Paul Gervais, Dr. Kowalevsky, and others; but only certain species or groups were fully treated, and we have never had any attempt at a monograph of the Sansan Mammals since Lartet's preliminary catalogue.

In the work before us we now have the whole series of these remains not only well described, but fully illustrated by excellent plates; and all who are interested in this branch of fossil zoology owe a debt of gratitude to Dr. H. Filhol, of the Paris Museum, for the execution of this laborious task. It appears that the Doctor has been in the habit of paying periodical visits to the Sansan quarries during the past three years, and has thus succeeded in obtaining a number of specimens which far surpass most of those hitherto described. Many of Lartet's types have also been fully described and figured for the first time.

The total number of species of Mammals which Dr. Filhol recognizes from these deposits is 78; these being arranged under the heads of 42 genera. In this notice we shall only refer to a few of the species which appear to us of especial interest. Before doing so, we venture, however, to call attention to some instances of carelessness on the part of the author which are exceedingly embarrassing to those who, like the present writer, have to record new genera and species. To begin with, Dr. Filhol never states which of the genera and species to which his name is appended are mentioned for the first time. In the absence of any back reference, it would, however, be natural to assume that when we meet with names like *Talpa primæva* (Filh.), on p. 35, such specific names are new ones. This, indeed, appears to hold good for that particular instance, and also for *Mustela leptorhyncha* on p. 105. When, however, we turn to *Mustela larteti* on p. 107, we find precisely the same condition, although this specific name was applied by the author in the "Bull. Soc. Philom." for 1888. A still worse instance occurs on page 265, where we find the name *Strogulognathus sansaniensis*, apparently as a new genus and species, without the slightest reference to the fact that the specimens so named had been described by the author in 1888 in the serial cited under the name of *Platuprosopos sansaniensis.* This change of the generic name has been rightly made on account of the preoccupation of the one first applied, but this ought to have been fully notified in the text. Moreover, when he was changing the name, the author might have given the correct *Strongylognathus* instead of the incorrect *Strogulognathus.* It may also be mentioned that in 1888 Dr. Filhol described a Mammal from Sansan under the name of *Choilodon elegans*, although no such specific or generic name occurs in the present work. Whether the omission of these names is due to inadvertence, or whether they have been replaced by others, we are quite unable to say.

Then, again, we notice some very embarrassing errors in regard to references, as well as a large number of misprints. Thus, in a footnote on page 133, the present writer is quoted as *loc. cit.* without the slightest previous mention of any work to which the *loc. cit.* could refer. As instances of carelessness in spelling, we may refer to the generic name *Lanthanotherium* given on page 23, but which appears as *Lantanotherium* on page 317; there being here, again, not the slightest reference that this name first appeared under the latter incorrect form (in which it has been quoted in two Manuals) in 1888. Again, on page 73 *et seq.* we are somewhat surprised to find *Pseudælurus* or *Pseudailurus* modified into *Pseudelurus*; but when we see the author's own genus *Proailurus* repeatedly appearing as *Prailurus*, our astonishment at the way words are treated is still greater. In the index the appearance of *Myogale sansaniensis* immediately after *Mygale sansaniensis* suggests an inadvertent repetition of a name, till we turn to the text and find that *Myogale* is a misprint for *Myolagus.*

We have alluded thus at length to these omissions and errors by which the work is disfigured, as they are so embarrassing to those who have to record and quote from it; but it is with pleasure that we turn to notice some of the more important forms described by the author.

Among the Insectivora, the author has found out that the commonly accepted name *Parasorex* is antedated by *Galerix*, which is accordingly adopted.

In the Carnivora, one of the finest specimens described (pls. ii. iii.) is a nearly perfect skull of *Machærodus palmidens*, which is of especial interest as showing the presence of an alisphenoid canal. This canal being totally wanting in all existing *Felidæ*, its presence in the Sansan *Machærodus* seems to indicate that this genus, although specialized as regards its dentition, is otherwise a generalized type. The other most interesting Carnivore is the one described by Lartet as *Hemicyon*, but referred by Gervais and Gaudry to *Hyænarctus*. The only specimen of this species that has hitherto been figured is part of an upper jaw with the hinder molars; but Dr. Filhol tells us that the species was originally founded upon the evidence of the mandible. An entire palate and mandible are figured in pls. vii.–ix., which sufficiently show that this animal does not belong to *Hyænarctus*, and as it is certainly not referable to *Cephalogale*, and according to Dr. Filhol is different from *Dinocyon*, it appears entitled to rank as a distinct genus. It may be observed that although the premolars agree with those of *Hyænarctus*, and differ from those of the Dogs, in the absence of fore-and-aft cusps, yet that there are four of these teeth, in place of the three of *Hyænarctus*; the whole four in the lower jaw forming a nearly continuous series. A further difference occurs in the narrower and more trenchant form of the hinder half of the lower carnassial tooth; while Dr. Filhol states that the feet of this animal were digitigrade, those of *Amphicyon*, and doubtless *Hyænarctus*, being plantigrade.

Another equally large Carnivore described by Lartet as *Pseudocyon*, but identified by Pomel with *Amphicyon*, appears likewise entitled to represent a distinct genus. This animal is unfortunately known only by the lower jaw, which agrees in general characters with the half-bear-like half-dog-like animals so common in the Miocene and Pliocene. It presents, however, the unique peculiarity that the first lower premolar is implanted by two distinct roots; the position of this tooth being far behind the canine, instead of close to it as in *Amphicyon*.

In the Ungulates we have a good figure of the skull of *Rhinoceros sansaniensis*, which is regarded as a good species; while a beautiful plate (pl. xvi.) of the jaws of *Anchitherium* with the deciduous and permanent teeth cannot fail to attract attention. Equally important is the fine skull of *Listriodon* shown in pl. xviii., which, in spite of its Tapir-like teeth, is clearly seen to be a true Pig. Space does not admit of reference to the numerous Deer-like Ruminants which are so abundant at Sansan; but we wish that Dr. Filhol had had an opportunity of comparing the jaw figured on pl. xxx. as *Strogulognathus* with that of the existing *Hydropotes*.

Passing by the Antelopes and Mastodons, our few remaining observations must refer to the subject which forms the crowning interest of the whole work—the identity of the limbs described as *Macrotherium* with the skull and teeth of *Chalicotherium*. The association of similar limb bones and teeth, not only at Sansan, but likewise at Pikermi and Samos, as well as in the United States, leaves no doubt that they belong to one and the same type of animal, although it may, of course, prove that there is more than a single genus. Dr. Filhol gives us not only figures of the bones of the feet, but also attempts a restoration of the skeleton. In the hind-foot, in spite of the long Edentate claws, the general structure is decidedly Perissodactyle; although this is much less marked in the carpus. The teeth, as is well known, are practically indistinguishable from those of some of the more generalized Perissodactyles; and, whether it be eventually proved advisable to retain *Chalicotherium* in that group, or to make it the representative of a distinct suborder of Ungulates, we cannot agree with our author in regarding it as in any way indicating an affinity between the Ungulates and Edentates, which, as has been recently pointed out by Dr. Ameghino, probably have a totally different phylogeny.

In congratulating Dr. Filhol on the completion of this valuable work, we cannot avoid expressing the hope that he may be induced to treat the Mammals of other gisements of the typical French Miocene in a similar manner. R. L.

III.—Guide du Géologue dans le Tertiaire Parisien. Par A. Laville. Pp. 24, Plates I.—X. (Paris, 1890.)

THIS *brochure* will prove exceedingly useful to all students of the Paris basin Tertiaries. There is no attempt at description of the beds; it commences with a table giving the subdivisions and groups of the divers formations within the area; followed by lists of the principal fossils found in them; and concludes with a series of ten maps of typical localities.

In the table the Meudon Conglomerate is classified with the Montian, whilst the Pisolitic Limestone is omitted, presumably because the author prefers to include it in the Cretaceous. The *Limnæa strigosa* marls form the superior limit of the Eocene, and the highest bed of the Oligocene is the Beauce limestone. We cannot agree with the author's classification of the Champigny limestone with the whole of the Gypsum beds; and we do not know how the lacustrine limestone of Ducy can consistently be bracketed with the upper, middle, and lower "sables moyens." If it is to be included in the last-mentioned division at all, it must be placed as the equivalent of the Mortefontaine beds. In regard to the fossil lists, which mostly deal with Mollusca, it is evident that the author has paid much more attention to some genera than to others. He is very ambiguous in his nomenclature, leaving it doubtful in the mind of the reader whether he intends the brackets to include genera, or subgenera, or merely discarded names. The maps form the most valuable portion of the work. They are extracted from the Government Surveys on the 80,000 scale, and clearly indicate the position of the chief sections found within the limits of each district defined. The ten plates of fossils illustrate many carefully-selected characteristic forms.

IV.—The Tertiary Insects of North America. By Samuel H. Scudder. Report of the United States Geological Survey of the Territories. F. V. Hayden, U.S. Geologist-in-Charge. Vol. xiii. 1890, 4to. pp. 734, pls. xxviii.

THIS massive volume contains the results of more than twelve years' labour devoted to the study of the fossil Tertiary Insects of North America, and even now only the lower orders of Insects have been fully treated; the materials collected within the last twenty years proving as abundant as all those hitherto known from the entire European area. In the Introduction the author remarks, "The pages and plates of the present volume bear testimony to the fact that our Tertiary strata have preserved remnants of an ancient host, so varied in structure, so closely also resembling their brethren of to-day, that nearly or quite every prevalent family-group in the entire range of the insect world has already been demonstrated to have then existed. While often fragmentary and crushed, sometimes beyond recognition, a not insignificant number are sufficiently preserved for us to repopulate the past; sometimes, too, they are preserved in such a wonderful manner that in tiny creatures with a spread of wings scarcely more than a couple of millimètres, one may count under the microscope the hairs fringing the wings."

There are several localities which have yielded the insects herein described, but by far the most important is Florissant, in a narrow valley high up in the mountains at the southern extremity of the front Range of Colorado. The insects are here preserved in an old lake basin, probably of Oligocene age, in shaly beds, now laid bare by erosion, which are wholly composed of volcanic sand and ash, and 15 mètres in thickness. These beds yielded a greater number of insects in a single summer than have been obtained at the celebrated Œningen deposit in thirty years, and a very interesting comparison is made of the percentage of representation of the different groups at the two localities. At Florissant the most numerously represented group is the Hymenoptera, which forms 40 per cent. of the total; followed by the Diptera with 30 per cent., the Coleoptera with 13 per cent., the Hemiptera with 11 per cent., and the Neuroptera with 5 per cent., whilst the Lepidoptera, Orthoptera, and Arachnida together only contribute ·54 per cent.

Great numbers of plants are found associated with the insects at Florissant, and both kinds of organisms indicate a climate considerably warmer than that now prevalent in the locality.

Of probably the same age as the Florissant deposit are the insect-bearing beds of the White River in Western Colorado and Eastern Utah, and of two or three localities in Wyoming. From fine clays of probably Miocene age, at and near Quesnel in British Columbia, Dr. G. M. Dawson obtained numerous insects, mostly Hymenoptera and Diptera; which Dr. Scudder has also described.

Of a more recent age are a considerable number of elytra and other remains of beetles, obtained by Dr. G. J. Hinde in clay beds near Toronto, Canada. Though only of interglacial age, the twenty-nine species determined by Dr. Scudder are all extinct; some of the forms are nearly allied to insects now inhabiting the same district in Canada and the northern United States, whilst the relatives of others now exist in the Lake Superior and Hudson Bay Region.

The author notices some peculiar general features relating to the occurrence of the fossil insects in North America; one, that in hardly a single instance has the same species been found in two distinct localities, a fact which may perhaps be accounted for by the beds not being exactly synchronous, and the author thinks that the insect remains will prove of more value in the marking of distinct horizons than the plants with which they are usually associated. Another feature is the number and extraordinary proportion of species each so far represented by a single specimen, and, again, that no inconsiderable proportion of the species must be referred to genera no longer existing.

The excellence of Dr. Scudder's work is too well known to require comment, and this present volume is an additional proof of the immense labour and zeal which he brings to his herculean task. Its importance will be fully recognized by all palæontologists on this side of the Atlantic, and its promised further continuance will be gladly welcomed.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 8, 1891.—Dr. W. T. Blanford, F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "The Cross Fell Inlier." By Prof. H. A. Nicholson, M.D., D.Sc., F.G.S., and J. E. Marr, Esq., M.A., Sec.G.S.

The tract of lower-Palæozoic rocks lying between the Carboniferous rocks of the Cross-Fell range and the New Red Sandstone of the Eden Valley is about sixteen miles in length, and little more than a mile in average breadth; the Inlier extends in a general N.N.W. and S.S.E. direction, and the normal strike of the rocks is about N.W. and S.E. The tract is divided along its entire length by a fault, which separates the Skiddaw Slates (with the Ellergill Beds of one of the authors and the Milburn Series of Mr. Goodchild) from higher beds on the west. A detailed classification of the Skiddaw Slates is not attempted, but the authors describe the succession of the rocks in the faulted blocks of the western portion. Their classification is as follows:—

Coniston Grits = Ludlow.
Coniston Flags (lower portion) = Wenlock.
Stockdale Shales = Llandovery-Tarannon.
Ashgill Shales.
Staurocephalus Limestone.
Dufton Shales and Keisley Limestone. } = Bala.
Corona Beds.
Rhyolitic Group.

A brief comparison of these rocks with those of other regions is made by the authors.

Two Appendices are added. One by Mr. Alfred Harker, M.A., F.G.S., contains petrographical notices of certain sedimentary and volcanic rocks in the Skiddaw Slates, of the volcanic rocks of the Eycott and Rhyolitic groups, and of the principal varieties of intrusive rocks. The second, by Mr. A. H. Foord, F.G.S., contains a description of some Cephalopods from the rocks of the Inlier.

2. "On the Igneous Rocks of the South of the Isle of Man." By Bernard Hobson, Esq., M.Sc., F.G.S.

Omitting the Foxdale Granite, the oldest igneous rocks of the island appear to be the diabase dykes of Langness, etc., intrusive in Lower-Silurian slates. The Crosby microgranite dyke is also intrusive in these beds, and though its age is difficult to fix, it is probably newer than the Foxdale Granite, which appears to be of post-Lower Silurian and pre-Carboniferous age.

Next come the volcanic rocks of lower-Carboniferous age—an augite-porphyrite series consisting of tuff, breccia, agglomerate, bedded lava, and intrusive masses exposed in a narrow strip extending from Poolvash to Scarlet Point. A vent seems to have been opened during or after the deposition of the Poolvash limestone, from which fine volcanic ashes were ejected to form marine tuff. At intervals between the eruptions the Poolvash marble was deposited, and became interstratified with the tuff. The vent then probably became plugged up, and a violent explosion following supplied material for the agglomerate overlying the tuff. Lava then welled forth, and finally the volcano became extinct, and the intrusive mass of the Stack, regarded by the author as a volcanic neck, was exposed by denudation. It was probably at the close of volcanic activity that a melaphyre dyke was formed resembling the porphyritic olivine-basalt of the Lion's Haunch, Edinburgh.

At Poortown an intrusive mass occurs, provisionally termed augite-picrite-porphyrite, and considered by Mr. J. G. Cumming to be of post-Carboniferous age.

Numerous dykes of ophitic olivine-dolerite occur between Bay-ny-Carrickey and Castletown Bay, at Langness, etc. They are post-Lower Carboniferous, and possibly of early Tertiary age.

Full details with regard to the development and the macroscopic and microscopic characters of the various igneous rocks are supplied by the author, who acknowledges his indebtedness to Prof. Boyd Dawkins for the use of his geological map and notes.

II.—April 22, 1891.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "Results of an Examination of the Crystalline Rocks of the Lizard District." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., V.P.G.S., and Major-General C. A. McMahon, F.G.S.

The authors, in company with the Rev. E. Hill, spent a considerable part of last August in examining anew those sections in the Lizard district which had any bearing upon the questions raised since the publication of Professor Bonney's second paper in 1883. They had also the advantage of occasional conference with Mr. Teall and Mr. Fox, whose valuable contributions to the knowledge of the crystalline rocks of the district are well known.

That the Lizard serpentines are altered peridotites may be regarded as settled, but doubts have been expressed as to their relation to other associated rocks, and as to the meaning of a streaky or banded structure exhibited by certain varieties.

The authors, after re-examination of a large number of sections, feel no doubt of the accuracy of their original view that the peridotite was intruded into the hornblende schists and banded "granulitic" rocks, after these had assumed their present condition. In it they find no signs of any marked pressure-metamorphism, either prior or posterior to serpentinization. They have failed to connect the streaky or banded structure with any foliation or possible pressure-structure in the schists, and they can only explain it as a kind of fluxion-structure, viz. as due to an imperfect blending of two magmas of slightly different chemical composition, anterior to the crystallization of the mass.

The Porthalla sections have been examined with especial care, not only because the serpentine is nowhere so conspicuously banded, but also because its intrusive character has been denied, both it and the hornblende schists being ascribed to the alteration of a series of sedimentary rocks of suitable composition. For this view the authors have failed to discover any evidence, and consider it contrary to stratigraphical and petrographical facts.

In regard to the genesis of the crystalline schists, which for purposes of reference were divided by Prof. Bonney into a "granulitic," a "hornblendic," and a "micaceous" group, the authors show that in parts of the first the more acid rock breaks through the more basic, as if intrusive, in others they appear to be perfectly interstratified, the one passing backwards and forwards, though rapidly, into the other. But between these extremes, intervals can be found where the two rocks seem as if partially drawn out together. The authors are agreed that certainly one, probably both, of these rocks are igneous, that when the basic rock was solid enough to be ruptured, the acid magma broke into it, and sometimes softened it sufficiently to allow of the two flowing for some little distance together, after which crystallization took place. In regard to the hornblende schists, the authors are not yet satisfied that either fluxion or mechanical crushing will account for every structure which they have examined, and prefer to leave the question, in certain cases, an open one. The most distinctive features of the micaceous group appear due to subsequent earth-movements, so that, though it exhibits some special characteristics, the authors are doubtful whether it is any longer worth while separating it from the hornblende schists.

Of the igneous rocks newer than the serpentine, the gabbro has received the closest attention. It exhibits in places (especially in the great dyke-like mass as Carrick Luz) a very remarkable foliation or even mineral banding, which has been claimed as a result of dynamo-metamorphism. The authors bring forward a number of instances to establish the following conclusions:—(*a*) That this foliation occurs most markedly where the adjacent serpentine does not show the slightest sign of mechanical disturbance; (*b*) that it must be a structure anterior to the consolidation of the rock; (*c*) that it sets in and out in a very irregular manner; (*d*) that when it was produced the rock was probably not a perfect fluid. Hence they explain it also as a kind of fluxion structure, produced by differential movements in a mass which consisted of crystals of felspar and pyroxene, floating thickly in a more or less viscous magma.

The authors' investigations tend to prove that (*a*) structures curiously simulative of stratification may be produced in fairly coarsely crystalline rocks by fluxional movements anterior to crystallization; and that (*b*) structures which of late years have been claimed as the result of dynamo-metamorphism subsequent to consolidation must have, in many cases, a like explanation. This is probably the true explanation of a large number of banded gneisses which show no signs of crushing and holocrystalline, but in their more minute structures differ from normal igneous rocks.

The authors have seen nothing which has been favourable to the idea that pressure has raised the temperature of solid rocks sufficiently to soften them.

2. "On a Spherulitic and Perlitic Obsidian from Pilas, Jalisco, Mexico." By Frank Rutley, Esq., F.G.S.

The specimen described is a leek-green rock with waxy lustre. The sequence of the structures developed in it is made out to be as follows:—First, the development of fluxion-banding; next, the formation of spherulites; and then the setting up of a perlitic structure, the fissures of which were finally sealed by the introduction of chalcedonic matter.

A wavy transverse banding in the spherulites is apparently due to a temporary check which the fluxion-bands have exerted on the development of the crystalline bundles of the spherulites. In one case a spherulite has been developed prior to the formation of a similar but larger one which encloses it. Some of the spherulites envelope small crystals of triclinic felspar.

The author considers it very probable that the obsidian has been subjected to hydrothermal agency since its solidification, and subsequent to the development of its perlitic structure, and gives reasons for this view.

III.—May 6, 1891.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "On a Rhætic Section, at Pylle Hill or Totter Down, Bristol." By E. Wilson, Esq., F.G.S.

In a deep railway-cutting at Pylle Hill, the Rhætic beds, having a thickness of not more than seventeen feet, are exposed between the Tea-Green Marls and the Lower Lias. There is no doubt as to the division between the Rhætic and Keuper beds in this section, but the line of demarcation between the Rhætic and the Lias has always been a matter of uncertainty in the West of England. In connection with this subject the term "White Lias," as applied to beds some of which are Rhætic and others Liassic, is held to be unsatisfactory. The author takes a limestone which is the equivalent of the Cotham Marble as the highest Rhætic bed in the section described. He divides the Rhætic beds of the cutting into an Upper-Rhætic Series and *Avicula-contorta* Shales. The intimate connexion betwixt the Tea-Green Marls and the Red Marls of the

Upper Keuper is well displayed, whilst there is a sharp line of demarcation between the former and the *Avicula-contorta* Shales. Most of the characteristic fossils of the British Rhætic are met with at Pylle Hill, together with a few forms which are new to England, and some of these possibly new to science.

A detailed section of the subdivisions of the Rhætic and adjacent beds, and a list of Rhætic fossils found in the section, are given by the author.

2. "A Microscopic Study of the Inferior Oolite of the Cotteswold Hills, including the Residues insoluble in Hydrochloric Acid." By Edward Wethered, Esq., F.G.S., F.C.S., F.R.M.S.

The author gives the following main divisions of the Inferior Oolite of the Cotteswold Hills in descending order:

Ragstones.
Upper Freestones.
Oolitic Marl.
Lower Freestones.
Pea Grit.
Transition beds resting on Upper Lias.

The strata are described, and the results of microscopic examination of the different beds given. These latter confirm the author's views as to the important part which *Girvanellæ* have taken in the formation of oolitic granules; whilst an examination of the borings referred to by Prof. Judd in the discussion of Mr. Strahan's paper "On a Phosphatic Chalk" convinces the author that these have no connexion with the genus *Girvanella.*

In the second part of the paper the insoluble residues left after treating the various deposits with acid are considered. They contain chiefly detrital quartz, felspars, zircons, tourmaline, chips of garnet, and occasionally rutile. In the argillaceous beds silicate of alumina was found to occur plentifully. The detrital material is considered to be due to denudation of crystalline felspathic rocks, and not of stratified ones. This view seems to be supported by the quantity of felspar and its good state of preservation.

The paper concludes with a consideration of the quantity of residue and the size of the quartz-grains in the different deposits, which are summarized in the following table:—

	Percentage of Residue.	Size of quartz grains, in millim.
Ragstones	2·8	·17
Upper Freestones......	1·1	·12
Oolitic Marl	3·2	·09
Lower Freestones......	1·8	·13
Pea-Grit Series	5·0	·14
Transition Beds	38·3	·13

This shows a great falling off in the percentage of residue above the Transition Beds. That of the Freestones is remarkably low, and it would appear that these rocks were formed under conditions which allowed of very little sediment being deposited.

ERRATUM.—In the May Number, p. 240, last line but one of first paragraph, *for* "Metamorphic" *read* "Metatropic."

CORRESPONDENCE.

ELEVATION OF AMERICA IN THE TERTIARY PERIODS.

SIR,—I notice in recent numbers of the GEOLOGICAL MAGAZINE that Mr. Upham has been discussing his views on the elevation of the Gulf of Mexico, etc. It seems a pity that gentlemen, who desire to launch such startling hypotheses, should not devote more time to settling the facts upon which these hypotheses are based, before promulgating their new views. As the statements made by Mr. Upham may by many be taken as properly verified, and more confusion be thereby occasioned, permit me to call attention to a few facts which have been verified.

1. The late Dr. Maack when on the isthmus of Darien did not collect any Pleistocene fossils from the summit of the Atrato divide 763 feet above the sea. 2. The Pleistocene fossils collected by Dr. Maack were from an elevation of only 150 feet on the Panama side, ten miles from Panama city. The fossils above this height collected by Dr. Maack are Eocene or Miocene exclusively, and related to the Miocene fauna of Santo Domingo, as indeed was pointed out by Gabb nearly twenty years ago (Proc. Am. Phil. Soc. vol. xii. p. 572). 3. The summit or dividing ridge is not fossiliferous, and is probably not later than the Mesozoic epoch.

I may add, from information to be shortly published, that the supposed great elevation of Florida at any time since the later Eocene is as improbable as any hypothesis which could well be conceived. The conclusions which the facts necessitate in the case of Florida may be briefly outlined as follows:—During the later Eocene, west central Florida was an island, like one of the Bahamas at present, composed exclusively of organic marine sediments which in the Vicksburg epoch attained an unbroken thickness of more than 1000 feet. The whole submarine plateau above which the present Florida rises may turn out to be of this age and constitution. This island had a land-shell fauna derived from the south. The strait between the island and the main coast north of it was more than fifty miles wide at the narrowest point, and was only closed at the beginning of the Pliocene. There have been gentle changes of level since the Eocene, but nothing violent, and the vertical range has been small. The Eocene and the old Miocene faunas were of a subtropical character like the Antillean fauna at present. A change took place in Mid-Miocene by which a cool, temperate, or colder water fauna invaded the Floridian region from the north, and about 200 feet of strata (Chesapeake Group) were deposited; equivalent to the well-known Miocene beds of Virginia and Maryland. With the elevation which connected the Floridian islands with the continent a warmer era was again inaugurated in the sea, and an invasion of Pliocene Vertebrates began, on the Peninsula of Florida.

There were unquestionably great changes of level on the continent, increasing as one goes northward, both in Miocene and Pleistocene times. In the Antilles it has been proved that great changes have taken place. But the Floridian region, for some unknown reason, escaped, and Yucatan, probably, also.

I have been making a special study of Floridian Geology for some years, and hope to publish a considerable amount of new information on that subject during the coming summer.

Smithsonian Institution, U.S. National Museum,
Washington, *April* 15, 1891.
Wm. H. Dall.

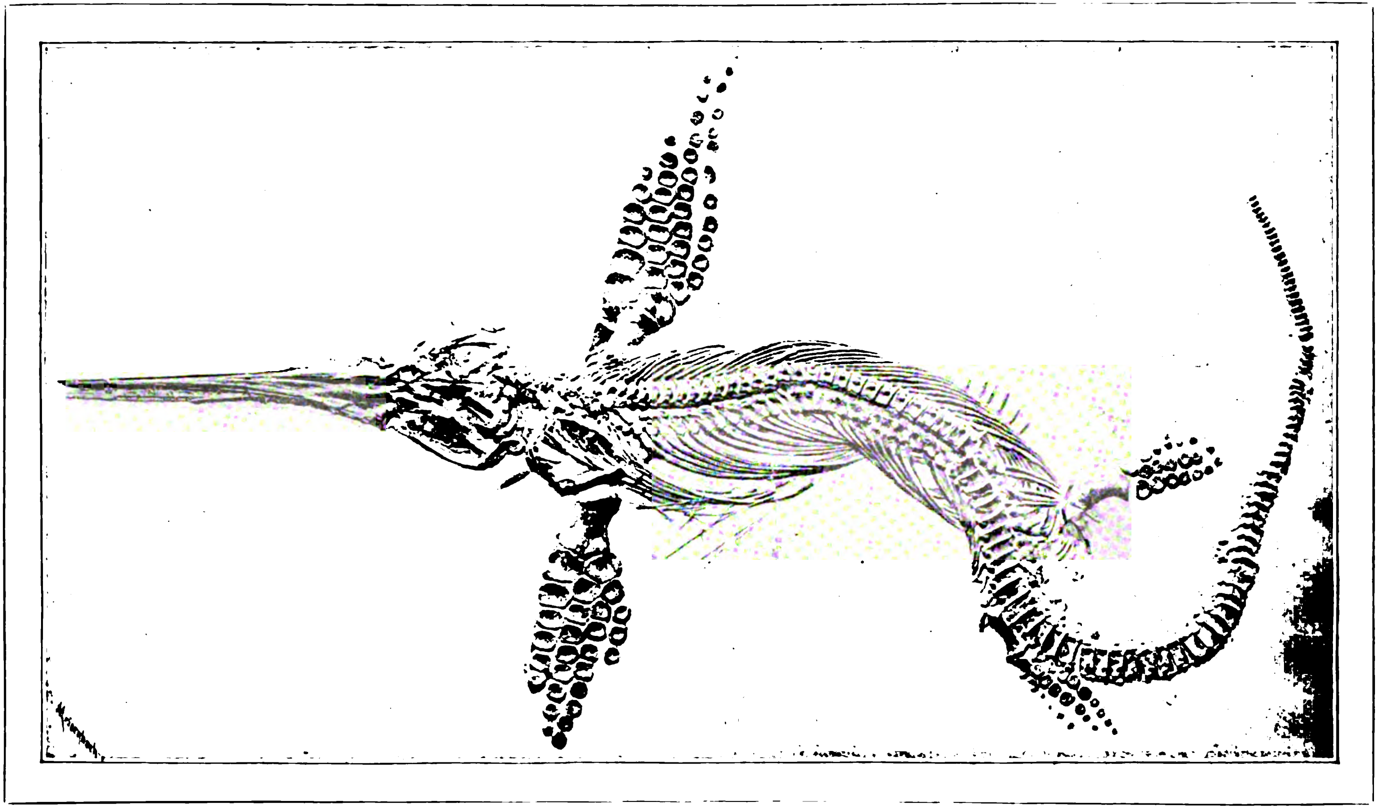
THE GEOLOGY OF THE SALT RANGE OF THE PANJAB.

Sir,—In the latest number (part i. vol. xxiv.) of the Records of the Geological Survey of India there is an interesting paper by Mr. C. S. Middlemiss on the Geology of the Salt Range of the Panjab. Admirable sections are given illustrating two points until recently in dispute, the positions of the Conularia Bed and of the Obolus Shales; and a very bold beginning is made of a fresh discussion, regarding the age and mode of origin of the Salt Marl and its minerals, advocating peculiar eruptive conditions connected with a primitive and hitherto undisturbed subterranean magma. Until Mr. Middlemiss developes his position, it would be premature to comment thereon; I will only ask leave to correct two personal errors in the paper. On p. 25 a quotation is made from my paper on the geology of the Panjab, published in the Provincial Gazetteer, whereby I am made to appear as executing an erroneous reversal of opinion upon a disputed unconformity in the Salt Range. Mr. Middlemiss must have overlooked the note at the beginning of the section on the Salt Range, stating that "this sketch is by Mr. Wynne." I did not alter a word of it. So the passage in question is a repetition by Mr. Wynne of a view against which I had remonstrated in vain. The other point is on p. 20, where I am represented as "not entirely agreeing" with the erroneous view of the Conularia horizon. It refers to a short paper in which I had endeavoured to soften a somewhat acrimonious dispute by an impartial summary of the evidence; but there can be no doubt as to which side my own opinion leaned. I even suggested the conclusion which Mr. Middlemiss now presents as established: regarding the "pebbles" with Conularia I asked—"Is it not more plausible to suppose that they were washed into the gravel bed from some contemporaneous (Palæozoic) pool deposit close by?" (Records, vol. xix. p. 133).

Clifton, 29*th April*, 1891.
H. B. Medlicott.

OBITUARY.

We regret to record the death of Professor Joseph Leidy, the distinguished American physiologist and palæontologist. The deceased, who was in his sixty-eighth year, was Professor of Anatomy in the University of Pennsylvania, and of Natural History in Swarthmore College. He was also President of the Academy of Natural Sciences of Philadelphia, Director of the Department of Biology in the University, and a Foreign Member of the Geological Society of London. His more important contributions to scientific literature were, "The Extinct Mammalian Fauna of Dakota and Nebraska," and "Freshwater Rhizopods of North America." He also wrote an elementary treatise on human anatomy.—*Standard*, Friday, 1st May, 1891.



Ichthyosaurus tenuirostris, Conybeare.

From the Lower Lias of Street, Somerset.

Presented to the British Museum (Nat. Hist.) by Alfred Gillett, Esq.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VIII.

No. VII.—JULY, 1891.

ORIGINAL ARTICLES.

I.—Note on a nearly perfect Skeleton of *Ichthyosaurus tenuirostris* from the Lower Lias of Street, Somerset.

By R. Lydekker, B.A., F.G.S., F.Z.S., etc.

(PLATE IX.)

SOME ten years ago Mr. Alfred Gillett observed in a quarry of the Lower Lias near his residence at Overleigh, Street, Somerset, a number of broken slabs of shaly limestone, containing portions of the skeleton of an Ichthyosaur. These slabs, which had been cast aside by the workmen, were fitted together by Mr. Gillett, who finally succeeded, after the expenditure of great pains, in skilfully developing from them an almost entire example of the skeleton of *Ichthyosaurus tenuirostris*, Conybeare.

With his usual liberality Mr. Gillett presented this remarkably beautiful specimen to the Geological Department of the British Museum (Natural History) in 1884, where it is now exhibited on the east wall of Gallery No. XI, forming one of the most striking objects in the fine series of Reptilian remains from the English Lias.[1]

The gift of this specimen to the Museum was particularly opportune, since the collection, although rich in some of the other species of the genus, was previously but poorly supplied with examples of *Ichthyosaurus tenuirostris*; and is even now widely distanced in this respect by the Dublin Museum of Science and Art. Mr. Gillett's specimen, of which we give a figure in Plate IX., although by no means a large example of the species, is one of the best preserved skeletons that have ever come under our notice. The animal lies on its ventral surface, with the back exposed and the limbs symmetrically expanded on either side; and it is largely due to the symmetrical position in which it has been preserved that the beauty and apparently unusual perfection of the specimen are due. Almost the only damage that the skeleton has sustained consists of some crushing of the skull, and the loss of a few of the tail vertebræ, and of some of the small bones of the paddles.

The fortunate rescue of this interesting specimen by Mr. Gillett affords a good instance of the value of local observers in preserving rare fossils which would be otherwise totally lost.

We may remind our readers that the species before us is not a typical representative of the genus *Ichthyosaurus*, of which the normal forms are *I. communis* and *I. intermedius.* In those species the front paddles are characterized by their great width, and the large number of longitudinal rows of ossicles entering into their composition. In the group represented by *I. tenuirostris*, on the other hand, the paddles are much narrower and longer, and have fewer rows of ossicles. Thus, as is well shown in our figure, the third digit, or the one taking origin from the intermedium of the carpus, consists of only a single row of ossicles; and there are usually only four rows of these ossicles in the entire limb, against seven or eight in the typical groups. Moreover, the radius—the bone lying immediately below the humerus on the front side of the limb—is a nearly square bone, with a notch on its front border; whereas in the typical group it is much wider and longer, and has no such notch.

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[1] The specimen is referred to in the Museum Catalogue of Fossil Reptiles, pt. 2, p. 84, No. R. 498 (1889).

All these characters indicate that the group represented by *I. tenuirostris* is much less specialized than the typical one, and thereby less widely differentiated from more ordinary reptiles. Indeed, so different is the structure of the paddles in *I. tenuirostris* and *I. communis*, that if we had these alone to deal with there could be but little hesitation in regarding the former as the representative of a distinct genus. Unfortunately (or perhaps our purely geological readers would prefer to say fortunately), however, there are certain intermediate forms which render it much more difficult to define such genera; so that for the present at least our species may rest in the genus to which it was referred by its original describer.

The specific characters of the present species are to be found in its long and slender rostrum, narrow fluted teeth, and the presence of a notch on the hinder border of the coracoid. Specimens in the British Museum with the rostrum still more elongated than ordinary were separated by Sir R. Owen as *I. longirostris*, but these proved to be identical with the earlier *I. latifrons* of König. The magnificent series of specimens from the Lower Lias of Barrow-on-Soar in the Dublin Museum indicates, however, that these variations are not of specific value, so that all these forms should apparently be referred to *I. tenuirostris.*

We may conclude this notice by calling attention to a point where the British Museum Catalogue is in error. It appears from the recent researches of Dr. E. Fraas that the type of *I. acutirostris*, Owen, has smooth carinated teeth, like those of *I. platyodon*, so that this species should be transferred to the Platyodont group, which it has been proposed to raise to generic rank as *Temnodontosaurus.* This leaves the name *I. quadriscissus* as the one best applicable to the other specimens catalogued as *I. acutirostris.* Moreover, Dr. Fraas considers that *I. zetlandicus*, Seeley, is identical with *quadriscissus*; and we are disposed to doubt the right of separating *I. longirostris*, Jäger (*non* Owen) from the same. Finally, we observe with satisfaction that Dr. Fraas is disposed to consider the American *Baptanodon* as inseparable from *Ophthalmosaurus* of the English Oxford and Kimeridge Clays, of which such a fine series has recently been acquired by the British Museum.

II.—The Perched Blocks of Norber Brow and their Levels relative to their Place of Origin.

By T. Mellard Reade, C.E., F.G.S., F.R.I.B.A.

IN a recent excursion the Liverpool Geological Society visited Norber Brow, near Austwick, to inspect the celebrated perched blocks of Silurian rock lying upon the Carboniferous limestone plateau. The visit was made in very appropriate weather during a storm of hail which added a weird element to the scene and heightened by contrast the blackness of the Silurian blocks. Since returning home I have re-read Prof. McKenny Hughes' interesting paper on the subject,[1] and find that generally speaking my notes and measurements are in accord with his. The angularity of the perched blocks, so different to the rounded and striated erratics of the Boulder Clay Plains of Lancashire and Cheshire, and the absence of Boulder Clay, is very striking, and inevitably suggests their transportal by glacier ice probably at the last phase of the glacial period.

It has, I believe, been generally taken for granted that these blocks are higher than their origin, and have been, as stated by Prof. Hughes, pushed up hill from the north.[2] Being specially interested in this question, which was raised on the spot by our excellent guide Dr. Ricketts, four of our party, after descending into the valley, climbed up the western side and traversed it northwards towards Crummack. The first object that attracted attention was a magnificent glaciated surface or *roche moutonnée* of Silurian rock on our left ascending the slope to the west transversely to the direction of the valley. On the right at about the level of the perched block on Norber Brow figured in Prof. Hughes's paper (p. 530), which I shall refer to as Perched Block No. 1, and which we took for our datum level, was what may be fitly described as a mason's yard of black angular Silurian blocks, as large or larger than those on Norber Brow. The bed rock was Silurian also and further northward up the valley appeared to be much glaciated. Continuing our ascent we reached the junction of the Silurian with the Carboniferous Limestone, and following the contour northward came upon a jutting crag of Silurian from which several huge blocks had separated at the joint planes a distance of a foot or two. These blocks had a slight cant down hill, and were just in a condition and position for transportal had the valley been filled with glacier ice. The upper surface of the crag appeared to be rounded. The rock evidently breaks up naturally into cuboidal masses. Here then was probably the origin of the blocks of Norber Brow, as according to the aneroid observations made by me and checked by Mr. Ashton Hill, C.E., this Crag is 265 feet above Perched Block No. 1 on Norber Brow. The highest point of the Silurians we tried by aneroid was 295 feet above the same datum. It is evident that the movement of the blocks towards Norber Brow was in accordance with the laws of gravity and downhill. A glacier filling the Crummack Valley would move southward and the blocks in question clinging to the west side of the valley might be stranded where they are found on Norber Brow. There is no doubt that the pedestals and platforms on which most of them stand, and which vary from one to two feet in height, are due to the wasting away of the surrounding limestone rock as pointed out by Prof. Hughes and Mr. Mackintosh, but I quite agree with Prof. Hughes that more data than are at present available would be required before any reliable estimate of the time that has elapsed since the close of the Glacial Period could be worked out.

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[1] On some Perched Blocks and Associated Phenomena, Q.J.G.S. vol. xlii. pp. 527–538 (1886).

[2] Q.J.G.S. vol. xlii. pp. 531 and 538.

These remarks are not intended to apply to the Silurian blocks above Settle, which Phillips states are 200 feet above any similar rocks in the district *in situ*.[1] As we did not see them or test their levels, any remarks of mine would be superfluous.

III.—THE LOWER CRETACEOUS SERIES OF THE VALE OF WARDOUR.

By A. J. JUKES-BROWNE, F.G.S., and Rev. W. R. ANDREWS, F.G.S.

IT has long been known that certain deposits of Lower Cretaceous age lay between the Gault and the Purbeck group in the Vale of Wardour, but the absence of any good open sections, along the tracts where they reach the surface, has hitherto prevented geologists from ascertaining the exact nature and succession of the beds.

Dr. Fitton, whose account of the Vale of Wardour is wonderfully good and accurate, distinctly recognized the existence both of Wealden and Vectian (Lower Greensand), stating that certain sands, containing traces of marine shells, occurred beneath the Gault and above the clays which he regarded as Wealden.

Mr. Bristow, however, when surveying the district in 1851 to 1853, does not seem to have obtained any evidence for the separation of the sands, and considered it safer to colour all the sands and clays below the Gault as Wealden until clear evidence of their marine origin could be obtained. Hence no Lower Greensand is indicated on the Geological Survey Map.

During last year we jointly resurveyed a portion of the ground on the six inch maps, and were able to obtain evidence that proved Fitton's view to be correct, and goes far towards completing our knowledge of the succession in this district.

This preliminary notice is printed by permission of the Director-General of the Geological Survey. Early in 1890 a well was sunk at Dinton, which gave us important information regarding the beds immediately beneath the Gault. The following is an abstract account of the section thus obtained.

		Feet.
GAULT	Yellow, brown, and blue clay (with fossils)	21½
	Sandy rock with a layer of small pebbles at the base (fossils)	14½
VECTIAN	Brown, grey, and yellow sands, with lumps and layers of ferruginous sandstone	26½
	Light grey sandy clay, becoming darker and passing down into stiff black clay	7
		69½

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[1] Rivers and Mountains of Yorkshire, 1855, p. 111.

One of the ferruginous layers in the sands has yielded a fairly good specimen of *Exogyra sinuata*, which is one of the most characteristic fossils of the Vectian group.

In this well the base of the group is evidently not reached, but most fortunately it is completed by a brook section at Teffont, which begins in a black clay exactly like that found at the bottom of the well. This black clay is about six feet thick, and passes down into a nearly black sand which has a green streak when cut, and consists mainly of dark-green grains of glauconite.

Underneath this sand are mottled clays, which were recognized by Mr. Whitaker as similar to the "catsbrain" clays of the Weald, —their tints are yellow and white, mottled here and there with a rich claret-coloured stain, which imparts a special character to the clay. Below are yellow loamy clays. We consider these to be of Wealden age, and the dark sand to be the base of the Vectian; but as the section is not clear, and this sand has not yet been found elsewhere, we cannot say whether the sand is conformable to the clays or not.

The maximum thickness of the Vectian appears to be about forty feet, and the yellowish-green sands which underlie the pebbly base of the Gault can be traced westward for several miles both along the southern and the northern sides of the Vale, overlapping the Wealden and the several divisions of the Purbeck beds, and gradually thinning out.

The thickness of the Wealden clays is difficult to estimate, because exposures are so few and the slopes are so gentle; but there can hardly be more than 40 or 45 feet at the east end of the vale, and they thin out rapidly towards the west, not extending far beyond Teffont on the north side, nor far beyond Sutton Row on the south side.

Eastward the Wealden occupies a certain width of flat ground which merges into the alluvium east of Dinton Station. At the cottages north of the station a well was sunk for about forty feet through yellow-grey and brown clays. We were informed that there was a perfect succession of clays without any sudden change or any pebbly bed, but that at the bottom there was *a floor of very hard sandstone.* The accuracy of this information we proved by having the well emptied, and the bottom tested with a punch. A piece of this sandstone was given to one of us by the well-sinker, and is a hard grey calcareous grit with *Cypridea punctata.* The material thrown out of the well also yielded *Cyprides, Paludina carinifera,* and *Unios.* We believe these clays to be of Upper Purbeck age, for the lower part of them, with a band of calcareous grit, exactly like that in the well, can be seen in the first cutting west of the station, and they are succeeded by a set of clays, marls, and thin limestones, which have a much greater resemblance to the Purbeck beds than to the Wealden.

When the railway was made there must have been an excellent section of these beds and the upper part of the Middle Purbecks in the two cuttings west of Dinton Station; now they are so overgrown that it is very difficult to make out the relations of the strata, for they are certainly flexured and perhaps faulted. We feel sure, however, that the beds in the first cutting are higher than those in the second, and we hope in a future paper to publish the evidence on which we base our conclusions. If our reading is correct, there is a well-developed Upper Purbeck series in the Vale of Wardour, with a thickness of 70 or 80 feet; and this is succeeded by representatives of the Wealden and Vectian series, which, however, are poorly developed and taken together are less than 100 feet thick.

IV.—THE RECENT AND RAPID ELEVATION OF THE HIMALAYAS.

By HENRY H. HOWORTH, Esq., M.P., etc.

IN the last Number of the GEOLOGICAL MAGAZINE my friend Mr. W. T. Blanford takes exception in very courteous terms to the views I have maintained in regard to the recent elevation of the Highlands of Eastern Asia. I cannot, however, quite grasp how far he agrees or disagrees with me. He does not apparently question the evidence which has so impressed experienced observers like Humboldt, Murchison, Tschihatcheff, Cotta, and Senkofski in regard to the absence of traces of widespread glacial phenomena in the high mountains of the Ural, the Altai, and the Thian Shan ranges, and which apart from all considerations seems to me inexplicable on any other theory than that these mountains did not exist during the so-called Glacial Period.

Mr. Blanford limits his criticism to the Indian evidence; but even here I do not quite understand what is the exact position he maintains. In the Manual of Indian Geology, that splendid encyclopædia of facts on whose title-page his name occurs with that of Mr. Medlicott, it is stated over and over again that traces of glaciation are nowhere present in peninsular India. In the same "Manual" it is argued that the so-called glacial phenomena which have been said to occur in the Punjaub and other parts of the Plains are to be otherwise explained, and I believe I am right in attributing to Mr. Blanford the view that the old glaciers of the Himalayas never protruded into the plains.

This limits the problem therefore to the Himalayas themselves. Mr. Blanford objects to Mr. Campbell's very emphatic evidence because he had never penetrated into the inner valleys, and only spoke of the outskirts where the valleys open out. This is true; nor does Mr. Campbell claim to have done more than deduce his conclusions from what he saw. He was a very keen observer, he had seen glacial phenomena in all parts of the world, he went specially to study glacial phenomena on the spot, and his descriptions of what he saw, which are very minute and graphic, seem to me to be most conclusive that the lower parts of the Himalayan valleys show no traces of glaciation.

But I did not quote Mr. Campbell only. General McMahon, who has studied and written much on the Himalayas, and published his observations in the Records of the Indian Geological Survey, is just as emphatic as Mr. Campbell. Lastly, it is true I have not myself been there, but I have seen many photographs, and many drawings, and notably the magnificent drawings of the Himalayan scenery by Colonel Trotter, which show the contour and structure of the valleys so admirably. These were exhibited only a few days ago at the Geographical Society, and I was struck, as other people were, by the angular, sharp, crisp outlines of the rocks and the absence of the peculiar curves that denote glacier action, and this not merely on the watersheds, but in the valleys themselves. The drawings, be it remarked, represented nearly the whole length of the chain.

I must not be misunderstood. I did not say in my paper that there are not traces of the glaciers having once extended further. I said very plainly indeed that there are such traces. Sir J. Hooker and Mr. Blanford proved this long ago. The Himalaya glaciers seem to me like glaciers in other parts to have shrunk considerably. What I do maintain is that these traces are only found when we have mounted the valleys several thousand feet, and that they are quite incommensurate in size and importance with the vast glacial *débris* and phenomena which should be found on the flanks and in the neighbourhood of these gigantic mountain buttresses if during the so-called glacial age they had formed the feature in the landscape which they do now. As gathering ground for ice at a time when Central Asia was occupied by water instead of being an arid plain, they are incomparably great, when contrasted with the Dovre Fjelds which shed their *débris* as far as the Carpathians, Central Russia, and Norfolk; or the Alps whose *débris* occurs down the Rhone valley as far as Lyons, and if they had existed in the so-called Glacial age we ought to find the great Indian plain strewn widely with unmistakable *débris*, instead of having to painfully search for it until we reach a height of 7000 or 8000 feet. I must, therefore, claim Mr. Blanford as supporting my conclusion rather than criticizing it. In regard to the main question, an important witness is Mr. Blanford himself. Let me quote testimony for which he was responsible when he was in the very thick of his geological labours in India, and long before he had largely forsaken the happy hunting grounds of Geology for those of Zoology.

On page lvi of the introduction to the Manual of Indian Geology, in discussing the origin of the Himalayas, we read, "The whole of the gigantic forces, to which the contortion and folding of the Himalayas and the other extra peninsular mountains are due, must have been exercised in the interval which has elapsed since Eocene times. . . . The direction of the Himalayan ranges is clearly due to post-Eocene disturbance. It will be shown, in the chapters relating to sub-Himalayan rocks, that the movement has been distributed over the Tertiary and post-Tertiary period; *and a great portion of it is of post-Pliocene date.*" Again, "As it is certain that a great portion of the disturbances affecting the Himalayan strata are of Pliocene or post-Pliocene date, it is reasonable to conclude that *at the close of the Miocene epoch no such mountain barrier as exists at present separated the Indian peninsula from Central Asia.* There is independent evidence in favour of the view that the elevation of the Thibetan plateau is of post-Siwalik date; for remains of *Rhinoceros* and other large mammals occur at an elevation of 15,000 feet in Thibet, and it is not probable that these animals lived in so elevated a region" (*id.* pp. 585 and 586).

Here is assuredly an important witness in support of the views of Falconer and of Strachey, behind whose broad ægis I claim to stand.

In conclusion, there are two statements in Mr. Blanford's communication which I wish to traverse. He says Mr. Lydekker is of opinion that the Rhinoceros remains from the Hioondes plateau are of Pliocene age. Mr. Lydekker was once of that opinion, but he subsequently withdrew it, and has printed his opinion that he now holds the beds in which they occur to be of post-Tertiary age.

In another venture Mr. Blanford says, "That if I had had an opportunity of seeing what is perhaps the grandest example of subaerial denudation in the world, I should be as little inclined as he is to believe that such gigantic furrows as the Himalayan valleys can have been ploughed out by rain and rivers since the frozen Mammoths were imbedded in the Siberian tundras."

My answer is that I do not for a moment believe that these furrows were ploughed out by rain and rivers at all, and that it seems to me as incredible to believe that the splintered precipitous and sharp-edged precipices of the Himalayan valleys were carved out by such agencies as that the Matterhorn or the pinnacles of the Sierra Nevada or other similar objects were thus shaped. The theory which attributes such forms to this kind of denuding agency seems to me absolutely transcendental, and to involve a *reductio ad absurdum* of Uniformitarian Geology.

V.—ON DYNAMIC METAMORPHISM.[1]

By the Rev. A. IRVING, B.A. and D.Sc. (Lond.), F.G.S.

IN the originally epistolary form of my previous communication[2] on this subject brevity was aimed at as far as possible. It was written at the time the letters therein referred to appeared, and my object in throwing out such suggestions as I have ventured to make, was to call the attention of writers on petrological subjects to the desirability of avoiding a certain looseness of thought, which seemed to attach itself not infrequently to the terms 'chemical change' and 'chemical action.'

Mr. Fisher's letter[3] in reply thereto is in reality an appeal from the creed of the geologist, not to *chemistry*, but to the creed of the chemist. I am certain it will satisfy no one who has made a real study of chemical physics.

The instances of the formation of CO and NO which have been cited, along with a good many of the immense number of "parallel instances" (*loc. cit.*), are very well known to students of chemistry; but they are not to the point. There is the error which mistakes the algebraic sum of the results of a chemical reaction (as expressed in thermal units) for pure chemical combination, *quâ* entry into atomic union. I thought that 'chemical combination' was a phrase sufficiently guarded, if taken in its technical and literal sense; and I still think so. All that Mr. Fisher's 'authority' has urged, and a good deal more, was before my mind when I penned the sentence: "It is something much more complex than that" (p. 563).[1] Mr. Fisher's authority thus takes a different ground altogether from mine, when he enunciates the doctrine that "many chemical changes are attended with the disappearance of heat." Of course they are. Why, every case of dissociation (which is a 'chemical change') is attended with the disappearance of heat or of an equivalent amount of electrical energy (in electrolysis). But all such cases will at once be seen to be rigidly excluded from the term "chemical combination." The fact is the term chemical change, as illustrated by the authority who uses it, covers the whole process of the reaction in each case; it includes the antecedent dissociation (or partial dissociation), bringing on what I have elsewhere called the "quasi-nascent state,"[2] which must precede the recombination of the atoms or radicles to form new molecules. It is of the latter only that I speak in my December letter; and it must be quite obvious that pressure is antagonistic to the former. We may put it thus:—If $\theta =$ the amount of kinetic energy manifested (*quâ* heat) as the result of a reaction of two bodies on one another; further, if we take $x =$ the amount of heat used up in the preliminary dissociation (or partial dissociation) of the antecedent molecules; and if $y =$ the amount of heat evolved in the recombination of the atoms thus rendered available; the very simple equation

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[1] Written in January last.

[2] See GEOL. MAG. Dec. III. Vol. VII. pp. 562–564.

[3] See the letters of Mr. Fisher and Mr. Harker in the GEOLOGICAL MAGAZINE for January, 1891.

$$\theta = y - x$$

seems to me to cover the facts of the case, in the simplest form in which the problem can be presented to us; as (*e.g.*) in the combination of two volumes of hydrogen and one volume of oxygen to produce steam. And if, as in a comparatively small number of cases, there follows a secondary dissociation into proximate constituents different from those which formed the antecedents of the reaction, calling the heat expended in this x', we get the equation

$$\theta = y - (x + x').$$

All that Mr. Fisher's authority has contributed then to the discussion is to inform us that in the cases he has cited (and there are plenty of others) the value of x (or in some cases of $x + x'$) exceeds the value of y, in which case θ is negative, and the phenomenon is *endothermic*. On the other hand, if the value of y

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[1] Those who wish for real information on the subject may be referred to Pattison, Muir's "Thermal Chemistry" (1885), and the English edition of Ostwald's "Outlines of General Chemistry" (1890), both published by Macmillan.

[2] See Chemical News, Nos. 1402 and 1505, "On Dissociation and Contact Action."

exceeds that of x (or $x + x'$), θ is positive, and the phenomenon is *exothermic.*[1] The subsequent, or even simultaneous absorption of heat by a diluent (such as nitrogen, in all cases of bodies burning in air) makes no difference, for this belongs to the *distribution* of the heat, and makes no difference in the *quantity of heat generated*, which is the same for the same weight of the same materials concerned in the same reaction.[2]

We know, for instance, that heat is used up (endothermic) in the reaction $C + CO_2 = 2CO$, for the simple reason that more heat is required to effect the dissociation $CO_2 = CO + O$, than is evolved in the subsequent combination (molecule for molecule) expressed by the equation $C + O = CO$; and we are pretty sure that this is the true explanation of the observed phenomena, because we know from independent evidence that the heat of combustion of C into CO is less than one-half of that of the combustion of the same amount of carbon in the reaction $CO + O = CO_2$. These facts have found their way for years past into such well-known text-books of chemistry as Williamson's "Chemistry for Students" (see § 60, 2nd ed.).

Again, in the case of NO we require the high temperature of the electric spark-discharge to effect the antecedent dissociation of the N_2 and O_2 molecules before we get NO formed; but in this case I am not at all sure that the phenomenon is endothermic, though the rapid distribution of the heat of combination may deceive us, if we lose sight of the all-important distinction between quantity and intensity of heat (absolute temperature).[3] The absence of explosive phenomena proves nothing as to this point. All this and a good deal more of like import has been discussed by myself and others in published papers during recent years.

The question raised practically resolves itself into this: Does pressure promote the dissociation of previously stable molecules, so as to render the intra-molecular energy of their atoms available for entry into new combinations? When this is answered in the affirmative on the strength of cogent evidence, I will gladly admit the 'storage of energy' (*quâ* potential energy of chemical affinity) in the crust of the Earth as the result of mere pressure. The latest grand conception of Mendeléeff as to the nature of chemical affinity points however exactly in the opposite direction.

In the cases of change of volume to which Mr. Fisher's authority refers, I suppose diminution of volume is meant. But I am not sure that the very molecular strain involved in surface-tension may not in these cases initiate chemical action; and a suspicion remains that the gases of the supernatant atmosphere may have something to do with it. I am not, however, acquainted with the details of the experiments referred to, nor do I think that for purposes of dynamical geology they are much to the point.

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[1] For a clear exposition of these principles see a paper by Spencer U. Pickering, F.R.S., on "Chemical Action and the Conservation of Energy," *Nature*, vol. xliii. pp. 165–167.

[2] Very well illustrated in the case of ammonia, which will burn continuously in pure oxygen, but not in common air.

[3] See my "Chem. and Phys. Studies, etc." p. 54.

It is stated that, "Whether it be atomic energy or not, is not at present known." Does this mean that we cannot distinguish between the energy of translation of the molecules of a gas or the energy of cohesion of the molecules of a solid, and the intra-molecular energy which the atoms possess *per se*? Is it meant to say that recent advances in chemical physics have not led to the recognition of the atom-temperature within the molecule as affecting for the time being the stability of the molecule itself? Does it mean to tell us that we cannot, in the light of a host of known facts, draw a distinction between those molecular moods or states of matter which we call magnetic and electric, and that interaction between the atoms which is concerned in building up those molecules, and which we call chemical affinity? Or, turning to his own chosen examples, can Mr. Fisher's authority bring forward any array of cogent facts to shake or overthrow the doctrine that the avidity with which CO takes up oxygen (whether free or combined) when the temperature is raised, and that most characteristic avidity with which NO takes up O_2 (at ordinary temperatures) is in both cases due, not to any force resident in the molecule as such, but to the *unsaturated valency* of the C-atom or the N-atom respectively? Intra-molecular energy seems to me as clearly distinguishable from molecular energy, as the latter is from "ordinary mechanical or molar energy."[1]

Reverting now to Mr. Fisher's original paper in the GEOLOGICAL MAGAZINE (July, 1890), I think I can follow his reasoning pretty clearly, until on p. 304 he says: "We must now inquire into what forms of energy the work has been converted." Here there seems to me some confusion of thought. 'Energy' is the capacity for doing work; that is, for producing or retarding motion, or overcoming resistance to motion. The amount of energy expended is always proportionate to the work done. In the case before us the energy is presented in the mechanical form of pressure, and if the lateral pressure is the result of the original 'energy of position' of another portion of the Earth's crust, the actual source of the energy is *gravitation* acting upon the mass favourably situated. This being in part resolved into lateral thrust, the energy of that thrust is expended in doing work which is distributed among the following terms:[2]—

1. The lifting of the cover (potential energy of position);
2. The elevation of the centre of gravity of the deformed mass, in so far as the extension of the mass takes place upwards (potential energy of position);
3. The work of compression (molecular friction generating heat);
4. The work of *shearing*, *bending*, and *fracture*.

Where I am unable to follow Mr. Fisher's reasoning is with reference to the last term, which is surely *outside* the others altogether.

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[1] Since writing this paper I have noticed that the above cases with some others are discussed in a very suggestive (though scarcely exhaustive) manner by Professor Liveing in his little book "Chemical Equilibrium, the Result of Dissipation of Energy" (1885).

[2] Referring to the geometrical construction used by Mr. Fisher (*loc. cit.*).

All that he considers the result of shearing seems to me the direct result of the lateral pressure; shearing, bending, and fracture being simply *concomitant items of expenditure* of the energy of the lateral pressure. Shearing, bending, and fracture are simply work done in opposition to the force of *cohesion*; the force, that is to say, which tends to maintain the molecules of a solid at fixed distances and in fixed relative positions, to which the undeformed mass owed such rigidity as it possessed; and this important factor Mr. Fisher seems to have overlooked. In both shearing and bending we must also have some molecular friction, with its thermal effect; but it is not easy to see how even this applies in the case of *fracture*, which is simply the work of overcoming cohesion. When Mr. Fisher says "this part of the *energy* is not convertible, etc.," he seems to me to be using the word 'energy' where he ought to use the term 'work.' Herein appears to lie the fallacy of the whole argument; and through this, as through a loop-hole, the idea of chemical action seems to insinuate itself.[1]

Turning now to Mr. Harker's letter, the first thing that calls for remark is the "*direct correlation of mechanical work and chemical energy*." This is very nicely put; so nicely that the unwary reader is easily led off the scent. On this I simply ask for an explanation of the word 'correlation.' What lies hid behind that rather big word is the gist of the whole question we are trying to solve. Sorby certainly *suggested* something of the sort; but we must have something more solid than suggestions, as a basis upon which to construct sound scientific theory. If Dr. Sorby or any one else will show how we can step by step follow such a transformation in harmony with what some of us *know* from years of thoughtful and fairly extensive study at first-hand of the facts and phenomena which form the groundwork of chemical theory, some real advance will be made. Until this is done, we shall have to regard the cited suggestion as no more than a gigantic guess. It may be useful in pointing the way to further investigation; but to draw deductions from it, as if it were a well-established induction, is altogether unscientific.

Mr. Harker refers, however, to experiments of Cailletet, Pfaff, and Spring, as affording practical verification of the suggestion of Dr. Sorby. Unfortunately this rough massing together of experimental evidence gives us a result of such a neutral character as we are familiar with in ordinary laboratory-processes of alkalimetry. I know some of Cailletet's splendid work very well, but this has hardly any bearing upon the question before us. If Mr. Harker refers to his experiments on the effect of pressure upon the interaction of zinc and sulphuric acid, or to those of Pfaff upon the interaction of hydrochloric acid and calcspar, and upon the combination of water with dehydrated calcium sulphate, they all tell against the notion of pressure helping chemical action. Pfaff draws this general conclusion from them: "It follows quite decisively from these experiments, that high pressure *intercepts* chemical affinity, when for its activity an increase of volume is necessary."[1] All this seems to have been clear enough to Mr. Harker some six years ago, when he wrote:[2] "The effect of increased pressure is to facilitate such physical and chemical changes as involve contraction of volume in the substances acted upon, and to retard changes which are accompanied by expansion." If he will furnish references to later work of Pfaff in which his conclusion cited above is superseded, he will confer a favour upon all who are interested in this fundamental question of petrology.

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[1] An illustration will perhaps make this clear. We may expend a definite amount of energy furnished either by the muscles of a horse or the fuel consumed in the fire-place of an engine in drawing a series of loaded trucks along a *perfectly horizontal* line of rails. Work is done in overcoming the friction of the wheels against their axles and against the rails, and in the displacement of a portion of the atmosphere with the movement of the train; but would any one contend that energy was stored up in the train?

As to the work of Dr. W. Spring, assuming that the alleged crystalline copper sulphide was proved to be a definitely crystallized chemical compound, we have to consider whether such alleged combination is accompanied by increase of density. We may attack the question I think fairly in this way:—

Assuming the following constants:—

	At. Wt.	Sp. Gr.
Metallic copper	Cu = 63·5	8·9
Elémentary sulphur ...	S = 32	2·07

and dividing each at. wt. by the sp. gr., multiplied into the molecular weight of water, we have for our present purpose,

$$63{\cdot}5 \div (8{\cdot}9 \times 18) = {\cdot}39 \text{ (vol. ratio of Cu atom):}$$
$$32 \div (2{\cdot}07 \times 18) = {\cdot}86 \text{ (vol. ratio of S atom).}$$

If the combination were merely 'additive,' we should have ·39 + ·86 (= 1·25) for the vol. ratio of the fundamental Cu S molecule.

But the sp. gr. of Cu S (crystalline) being 4·6, we get

$$(63{\cdot}5 + 32) \div (4{\cdot}6 \times 18) = 1{\cdot}14$$

for the actual vol. ratio of the same molecule. This tells us plainly enough that the union of atoms is accompanied by an *increase of density*.

Mr. Harker is careful to point out the necessity for keeping the apparatus cool in the experimental work of Dr. Spring, as cited by him. Where, one may ask, would be the necessity for this, if (i.) there were no heat generated by friction during compression; (ii.) the process of chemical combination (as alleged) were endothermic? We have no right even here to say that any portion of the mechanical energy is transformed into chemical energy. The chemical energy was potentially already in the atoms of Cu and S respectively, as a function of their atomic weights (according to one of the latest generalizations of chemical science); all that the pressure did in the experiment in question was to coerce them into such intimate contact as to bring them *within the field of its operation.*[1] This, too, seems to be Spring's own interpretation of the results obtained.[2]

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[1] See *Allgem. und Chem. Geol.* pp. 308–310: "Es geht also aus diesen Versuchen ganz entschieden hervor, dass starker Druck die chemische Verwandtschaft dann *aufhebt*, wenn zu der Entfaltung ihrer Wirksamkeit eine Volumvermehrung erforderlich ist."

[2] Brit. Assoc. Report, Aberdeen Meeting (1885), p. 846.

A case, the exact reverse of that of Cu S, has been established by the more recent work of Dr. Spring in conjunction with Van 't Hoff.[3] The substance acted upon was the double acetate of copper and lime. The formula for this double acetate is $Cu(C_2H_3O_2)_2+Ca(C_2H_3O_2)_2+8H_2O$, and it occurs as 8-sided prisms of the quadratic system. It is gradually built up with the aid of moderate external heat by adding gradually free acetic acid to a warmed mixture of equivalent proportions of neutral acetate of copper and slaked lime in water.[4] The process is a complicated one; but it is not reversible, for in the experiment referred to the double acetate is resolved by a pressure of 7000 atmospheres into the two separate acetates of copper and lime with the separation-out of some of the water of constitution, the same change in fact as is effected by heating the salt above 75° C. at ordinary atmospheric pressure. The effect of pressure here is again to effect a transformation which is accompanied by loss of volume; tending to give greater closeness to the atoms until they obtain that configuration which belongs to their most stable relation. We may compare it with the action of heat in breaking up the molecules of ammonium nitrate to such an extent as to allow the atoms to rearrange themselves (with evolution of heat) in the more stable compounds N_2O and H_2O. The fact is one which, taken along with the case of Cu S, is of far-reaching significance, but cannot be followed up further here. So far as it goes, it lends support to a 'diagenetic' rather than to an 'epigenetic' theory of metamorphism.[5]

Mr. Harker misrepresents me, when he suggests that I have assumed that "the whole of the work done in the compression, deformation, and friction of rocks passes into heat." I have never assumed anything so nonsensical, as Mr. Harker may see, if he will do me the favour of making a more intimate acquaintance with my little work, to which he refers. Neither he nor I was dealing with a case of 'deformation,' but with a hypothetical case of what Heim calls 'überlastet,' the condition, that is to say, of 'latent plasticity' antecedently to deformation, where the burden upon the deep-seated rock-mass produces hydrostatic pressure greater than the internal resistance to deformation which the cohesion can offer. All that

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[1] This was pointed out by me in App. ii. note D of my original thesis written in 1887 (see "Chem. and Phys. Studies," etc., p. 108).

[2] See "Am. Journ. Sci." vol. xxxv. (1888) p. 78, and vol. xxxvi. (1888) p. 285, *et seq.* I am much obliged to General MacMahon for furnishing me with these references.

[3] See "Zeitschrift für physik. Chemie," i. 5, cited in 'Nature,' vol. xxxvi. p. 160.

[4] Wislicenus, "Organische Chemie," pp. 541, 542.

[5] From certain known facts, it does not seem at all improbable that such complex syntheses may have taken place extensively in the early stages of the genesis of rock-forming minerals. Among them I have suggested ("Chem. and Phys. Studies," etc., App. ii. note Q) the formation of minerals of the spinel type, in which Al_2O_3 plays the part of an *acid*, the alumina being set free with subsequent alteration of physical conditions, to enter into new relations as a *base*.

I have maintained is that during the compression-stage you must have molecular friction (or something equivalent thereto), just as, while crushing is going on, you must have molar friction (if the phrase may be allowed); and in both cases you must get *some* of the energy expended manifested kinetically as heat. My real contention was, that the *intensity* of such heat would be too low for it to be of any practical importance.

To sum up, I must confess that in the light of what has been adduced in this paper, I see no reason for unsaying or qualifying anything in my previous letter[1] (December, 1890), though I am very sorry if any one's susceptibilities have been wounded. It was quite unnecessary for Mr. Harker to offer me any apology; but I am a little surprised that he should not have read what was put into print as a criticism or stricture upon his own most valuable essay, which was printed in the Report of the Brit. Assoc. in 1885.

The one great factor of mineral change at depths is *superheated water*,[2] the existence of which is dependent on pressure. This both Mr. Fisher and Mr. Harker seem to have overlooked. But the experiments of Daubrée and others go to show that its action is in many cases in the direction of the resolution of higher and more complex compounds into simpler and denser mineral forms, rather than in the building-up of more complex out of simpler compounds.

[Since this paper was written I have received from M. Troutschoff of St. Petersburg, a copy of his interesting paper in the "Comptes Rendus," in which he gives an account of his method of preparing crystalline quartz from a dialysed solution of silica in water by prolonged heating in hermetically-sealed tubes; and in "Nature," vol. xliii. p. 545, the somewhat startling announcement appears of his successful achievement of the *synthesis of hornblende*, by a similar method, out of the various oxides which generally enter into the composition of that mineral. These were obtained partly as dialysed solutions, partly as fresh-precipitated hydrates, and mixed in right proportions as such. Each tube before sealing up was exhausted by a Sprengel pump, so that probably most of the uncombined water was drawn away as vapour along with the air. The sealed tubes were heated in a specially-constructed sand-bath for three months to a temperature of 550° C. Under these conditions the synthesis of hornblende crystals was effected, together with some pyroxene, a zeolite, and a variety of orthoclase; and it is not difficult to see that here synthesis of the denser minerals was facilitated by the action under great hydrostatic pressure of the superheated water which remained in the tubes, and separated out from the hydrated materials as the digestion proceeded. M. Troutschoff applied in fact the conditions which may easily be conceived as having obtained generally in the genesis of the heavier minerals of the Archæan schists. See my work (*Ibid*, pp. 68, footnote, and 91, 95, 96).]

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[1] With one exception, which no one has noticed. When I said 'shear-planes' I should have said 'shear- and thrust-planes.'

[2] Compare pp. 10–15 of my "Chem. and Phys. Studies in the Metamorphism of Rocks"; also the quotation from Pfaff in App. ii. Note K. The work of Pfaff is not as well known as it should be by English geologists.

VI.—Rutile in Fireclays—Reply to Major-General MacMahon.

By W. Maynard Hutchings, Esq.

In the June Number of the Geological Magazine, p. 259, Major-General MacMahon deals with my paper on fireclays, etc., and raises, with much fairness, several objections to some of my interpretations and inferences. Some of the criticisms are exactly what I should expect to be made, and were more or less present in my own mind, so that I can well see how they may arise in the minds of others.

General MacMahon appears to have somewhat overstated my views as to the "dynamic" part of the "Metamorphism" in question, owing to taking all I say as equally applying to slates and clays, which is not the case. Thus, the paragraphs he refers to on p. 168 will, I think, plainly show that I distinguish between what has taken place in clays and allied shales, and what has taken place in slates; and passages in my previous paper make this still more evident. I fully hold that slates, such as I refer to, have undergone metamorphism of very "dynamic" nature. And I hold that the beginnings of the same thing went on in the clays and shales, but in a so much less degree that I think General McMahon would fully admit it.

All I claim for the clays is summed up in the sentence at bottom of p. 316 (July Number of last year), where I speak of "the joint action of pressure, warmth, and mineral solutions" as the probable condition of the changes I believe to have taken place. It was only, I think, in replying to Dr. Irving that I used the word "dynamic" at all in connexion with the clays and shales of the Coal-measures. It may be that it is a wrong expression in that combination.

"Dynamic" and "Metamorphic" are dangerous words, perhaps, as they are used so variously by those we look to for light and leading that we hardly know how to use them safely at all.

Such changes as I believe to have taken place in fireclays would not, I assume, be brought about unless the chemical action had been intensified by warmth and *pressure*. That they have been under conditions capable of producing the pressure and warmth is hardly to be doubted.

What are we to call the effects of these things, as distinguished from any ordinary surface-weathering due to simple chemical action? Would "pressure-metamorphism" be allowed to include them? Where does simple chemical action end and "metamorphism" begin?

I at once admit what General MacMahon says as to absence of direct chemical evidence for my views. It is, very unfortunately, a fact that lack of chemical work is felt throughout a great deal of the petrological study that is going on. We have many workers with the microscope, but very few workers with the balance.

In the present instance, however, the nature of the material is such that I do not think the most devoted analyst could obtain very much solid evidence.

The "pestle and mortar" business was not so violent as General

MacMahon seems to infer, the trituration of a clay ("without grinding") partly in water, being a gentle operation. But, violent or gentle, I fail to see that it has any bearing on the fact, on which stress is laid, that after separation none of the larger flakes of mica contain any rutile at all; nor on the conclusion which this fact enables us to draw, in view of what we know of the nature of the materials forming these deposits, that the rutile was not brought into the sediments in the mica, as such.

As regards the fact that the mica of these "complex flakes" containing rutile is orientated in all directions, I do not look upon it as of much importance one way or other. General MacMahon thinks that if the mica is secondary the "molecules of mica would, at the moment of crystallization, surely have followed the laws of crystallization and have arranged themselves in definite order." This is simply an *à priori* supposition as to what *ought* to take place, and can hardly count as an argument. As a matter of fact, observation of mica which is formed as a secondary product in altering felspar, either in crystals of felspar or in fine felspathic ash-material, seems to show that no such definite order is by any means the rule, but rather in most cases quite the reverse. Such, at least, is my experience with materials of this nature of which I am just now making a special study.

It is suggested that the micaceous ilmenite may be the source of the rutile. I do not think examination of the materials could lead anybody to this view. I regard this mineral as secondary, and derived indirectly from the same source as the rutile. I do not know that the transparent and translucent micaceous ilmenite as it occurs in these clays, etc., and abundantly in some slates, has ever been regarded as anything but secondary, nor that any original rock has been suggested whence it could be derived clastically.

Finally, while admitting the full force of some of General MacMahon's criticisms, I venture to think that the subject should be looked at and judged a little more *as a whole*, taking in what I might call outside matters as well as details of the laboratory and the microscope.

Broadly, the matter stands as follows: We have these large and extended deposits of the Coal-measures all apparently similar in nature, derived from similar sources. All the evidence obtainable goes to show that these sources were granites or gneisses. There is not any evidence of any sort to show that any other class of rocks was concerned in supplying the sediment, and I am not aware that any student of them, in the field or in the laboratory, has ever suggested another origin for these beds, either wholly or partially.

A portion of these deposits, the clays, contains these vast numbers of rutile-needles. I suggest that these are of secondary origin, formed *in situ*, and I think they result from the decomposition of biotite-mica, which can be seen to have formed so large an item in the original sediment; because biotite when tested has been found to contain titanic acid, and because it has been observed, under some conditions, to give rise to rutile during its decomposition.

The needles of the fireclays may, however, be secondary and yet not be derived wholly or even in part from the biotite. Some other mineral, sphene for instance, may have been the parent, though, as intimated in my paper, it does not seem so likely.

If the rutile is not secondary, it must have been brought in with the original sediment. I consider it may be looked on as shown that it was not contained as such in the original mica. Whence did it come? Can anybody point to granites or gneisses containing rutile-needles in the abundance required for these extensive deposits, and containing them, moreover, not in the mica, the usual way in which they do occur when seen at all? If, in spite of all the evidence on this head, it is assumed that some other rock and not granite or gneiss was the source of these deposits, then what rock can be suggested which supplied the rutile and the mica? And if it be supposed that this other rock supplied only a *part* of the total materials, but *all* the rutile, then it would be still more interesting to have that rock named. It is easy to say the needles came from elsewhere; but where did they come from?

The subject of the origin of the minerals in these special clays, etc., is of much interest, because it may throw light on the genesis of slates and phyllites, a question which has given rise to much speculation and discussion and received great attention from some of the leaders in petrological work. It is a somewhat difficult subject to deal with, and I would be the last to think that my own suppositions and theories are in any way proved to be more than attempts at an explanation. I only venture to hope that they are not quite out of harmony with the other evidence, which seems so strong, as to the original nature of the deposits; and to think that if they are disputed, if the secondary nature of the rutile is denied, some other definite source for it should be suggested, which should at the same time harmonize with the other facts of the case.

NEWCASTLE-ON-TYNE, *June*, 1891.

VII.—ON THE BRITISH EARTHQUAKES OF 1889.[1]

By CHARLES DAVISON, M.A.,
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(*Continued from page* 67.)

2. LANCASHIRE EARTHQUAKE: FEB. 10, 1889.

Time of occurrence, 22h. 36m.: Intensity, VI. Epicentrum about two miles N.N.E. of Bolton, half a mile west of the village of Bradshaw.

This interesting earthquake affected a district for the most part thickly populated, and the accounts of it are consequently numerous. In the newspapers mentioned below, records are given of observations from 156 towns and villages, situated within a nearly circular area about 55 miles in diameter. Considering the smallness of this area,

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[1] The Map will appear with Part III. in the August Number GEOL. MAG. —EDIT. GEOL. MAG.

I suppose that but few previous earthquakes have afforded materials so abundant for the seismologist.

Accessory Shock.—It is probable that at least one slight accessory shock occurred between ten and twenty minutes after the principal shock. Near Blackburn, where the intensity was V., an observer residing at Wilpshire "noticed a slight recurrence of the phenomenon some time afterwards—about twenty minutes." At Prestwich, the intensity was about, or perhaps more than, IV., and there "another but feebler shock took place—perhaps some ten minutes afterwards." The evidence is clearly incomplete, but it seems most probable that both accounts refer to the same shock, which, owing to its very slight intensity, escaped detection elsewhere.

Disturbed Area.—As in the previous earthquake, the places where the principal shock was undoubtedly felt are indicated by small discs, and those where there is good reason for believing that it was not felt by small crosses (×). For the former, I have relied almost entirely on the numerous accounts given in the local press; for the latter, on inquiries made in the district with the view of determining the exact form of the disturbed area. In the immediate neighbourhood of the boundary, the evidence is somewhat scanty, and especially is this the case near Glossop and in the Peak country. Having, as will be seen, no positive evidence from the latter district, the outline in this part cannot be regarded as very exact.

So far as we can judge from the materials collected, the outline of the disturbed area seems to be approximately circular. It will be seen, from the table of intensities given below, that the boundary corresponds to an isoseismal line of intensity less than IV. and greater than III. Outside this area, it is possible that the shock may have been felt, and probable that it would have been detected by any one accustomed to the observation of slight earthquakes. But that it could have been felt as far as Birmingham, as one observer states, is clearly impossible, first, on account of its distance from the rest of the disturbed area, and, secondly, because it was not registered by one of Prof. Ewing's delicate seismographs erected there in my cellar.

The disturbed area, thus defined, is 56 miles from north to south, and 54 miles from east to west; and includes an area of about 2480 square miles.

Time of Occurrence.—The records of the time of occurrence can, unfortunately, lay claim to no great accuracy. So far as I know, the earthquake was registered by no instrument of precision. Excluding, however, all estimates that are admittedly approximate, we have the following definite records. In the immediate neighbourhood of the epicentrum, where the intensity was not less than VI., it was noticed at Bolton at 22h. 35m.; at Turton, at 22h. 36½m. by one account, and 22h. 37m. by another. Outside this range and within the isoseismal of intensity V., we have the records of 22h. 35m. at Farnworth, of 22h. 37m. at Accrington, of 22h. 38m. at Rochdale, Heywood, Bury, and Prestwich; of 22h. 40m. at Tyldesley and Wigan; and, lastly, of 22h. 25½m., clearly wrong if it refer to the same shock, at Radcliffe. Between this last isoseismal and the boundary of the disturbed area, the following times are given: 22h. 32m. at Rusholme, 22h. 37m. at Greenhalgh, Preston and Meltham; 22h. 43m. at Marbury (near Northwich), and 22h. 45m. at Waterhead and Heaton Chapel.

From this evidence, I have indicated 22h. 36m. as the probable time of occurrence at the epicentrum. If the average surface-velocity of the earth-wave were 1200 feet per second, the shock could be felt at the limits of the disturbed area about two minutes later. But the records in all parts of the area are too discordant to lead to results of any value.

Nature of the Shock.—The descriptions I possess of the nature of the shock are, with one exception, derived entirely from newspapers, and cannot always be closely trusted. As a rule, they are too vague and inexact to justify detailed quotation. There can be no doubt, however, that the character of the shock, especially with regard to the number of vibrations felt, was subject to considerable variation throughout the disturbed area; but this we should be led to expect from Prof. Milne's seismic survey of an area of about nine acres in Tokio.[1] In the present case, it is possible that these variations may in part be attributable to the form and position of the seismic focus.

From a very large number of accounts, I select the following as fairly typical of the different effects observed:—

Bolton: a distinct heavy rumbling for a few seconds, and, mingled with it, a sharp thud like an explosion.

Bury: a rumbling noise, lasting about four seconds, and then a sort of heavy thud, as of some enormous weight dropping on the floor, causing an alarming vibration and a rattling of window-frames.

Prestwich: a shock as of a heavy falling body, which caused the windows to rattle loudly; two or three seconds later, a second thud-like shock of somewhat greater intensity than the first; followed by gentle, but distinct tremors, lasting, perhaps, twenty or thirty seconds more.

Chorley: a noise like the rumbling of heavy waggons on a stone pavement was suddenly heard, and, along with it, a few sharp thuds were felt, accompanied by a vibratory motion of the earth.

Bowdon: a sudden jar was felt, like that produced by a heavy body falling, or by the slamming of a heavy door; then the floor vibrated three times distinctly; and this was followed after a few seconds by another slight vibration, a double one.

Bolton and Bury, it will be seen, are close to the epicentrum of the earthquake, and, at both these places, a single thud, or prominent vibration, was felt. It follows, then, that the double or multiple vibrations observed in other parts of the district cannot have been due to a recurrence of the shock near the same spot as the first; and it seems almost impossible to suppose that they were produced by repetitions of the initial disturbance in different parts of the area. We must conclude, therefore, that the nature of the shock varied with the position of the place of observation relatively to that of the seismic focus, or with the geological structure of the surrounding country.

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[1] Japan Seism. Soc. Trans. vol. x. pp. 1–36.

Now, a single vibration was felt at: (*a*) Blackburn, Bury, Meltham; (*b*) Bolton, Heywood, Ramsbottom, Wigan; a double vibration at: (*a*) Longridge, Prestwich, Rhodes; (*b*) Burnley, Leigh, Marbury, Nelson; three or more vibrations at: (*a*) Chorley, Failsworth, Hollinwood, Middleton, Stretford, Whitefield; and, lastly, a tremulous or continuous vibration at: (*a*) Bowdon, Crompton, Darwen, Manchester, Preston; (*b*) Leftwich, St. Helens, Tottington. The direction of the Irwell fault in the neighbourhood of the epicentrum is approximately N.W. and S.E., and, if lines be drawn through the epicentrum from north to south and east to west, they will divide the disturbed area into four quarters, so that places on the N.W. and S.E. quarters are more nearly in a line with the Irwell fault than places in the N.E. and S.W. quarters. Places in the former pair of quarters are preceded by the letter (*a*) in the above list, and places in the latter pair by the letter (*b*). The results may thus be summarized:—

	a.	*b.*	Total.
Single vibration	3	4	7
Double or multiple vibrations	14	7	21

In the majority of cases, then, double or multiple vibrations were felt at places nearly in a line with the Irwell fault at Bolton; and a single vibration at places whose directions relatively to the epicentrum are nearly at right angles to this direction.

On the vertical component of the motion, very few observations seem to have been made. The movement is described as an upheaval simply, at Chorley, Eccles, Farnworth, Nelson, Oldham, and Wigan; but it is not stated whether the upheaval was followed or preceded by a lowering, or even whether it was accompanied by any such movement in a contrary direction at all. These places are not confined to any particular part of the disturbed area. On the other hand, at the following places, there was first a rise, followed by a lowering of the ground.

Ramsbottom: persons felt as though they had been bodily lifted up and dropped quickly.

Heywood: the sensation was that of a sudden lifting of the dwelling and of as sudden a sinking.

Bury: persons in bed felt as if their beds were raised for a brief time and then allowed to fall.

Prestwich: a jerk up and down, followed by a trembling movement.

These four places, it is important to notice, lie on the north-east side of the Irwell fault, and at only a few miles distance from its intersection with the surface.

Duration.—If, as I believe, the earthquake was due to a slip of the Irwell fault in the neighbourhood of Bolton, and if that slip was confined, not to a point, but to a definite area, we should expect the duration of the shock, as well as its nature, to vary throughout the disturbed area. The duration should of course be greatest at places in the line of direction of the fault, and shortest at that place situated so that a line joining it to the centre of the seismic focus is perpendicular to the fault-plane. On the other hand, the apparent duration depends on the distance of the place of observation from the focus, and, what is far more important, it depends on the power of the observer to detect the faint initial and final tremors. On this account, chiefly, I think it is not possible to discover any certain law in the distribution of places according to the duration of the shock felt there. In this respect, more may be learnt from the duration of the sounds.

The following are the recorded durations of the shock:—

About	15	seconds.	Farnworth.
,,	6	,,	Blackburn, Bolton.
,,	5	,,	Crosby, Heaton Chapel, Melling.
,,	4	,,	Chorley.
,,	3	,,	Prestwich.
,,	2	,,	Bacup, Cheetham Hill, Crumpsall, Darwen, Meltham, Preston, Waterhead, Whalley.
,,	1	,,	Leftwich, Oldham, Tyldesley.

Intensity.—In the following lists are given the names of the places where it was possible to determine the intensity according to the Rossi-Forel scale.

VI. Bolton, Ramsbottom, Tottington.

V. or VI. Bury, Chesham, Farnworth.

V. Besses, Blackburn, Chorley, Darwen, Golborne, Heywood, Horwich, Hulton Park, Ince, Rochdale, Turton, Whitefield, Wigan.

IV. or V. Blackley, Castleton, Cheetham Hill, Crumpsall, Harpurhey, Littleborough, Middleton, Prestwich.

IV. Accrington, Altrincham, Bolton-by-Bowland, Bowdon, Breightmet, Cheetham, Eccles, Facit, Heaton Park, Lees, Leigh, Leyland, Little Hulton, Manchester, Milnrow, Newhey, Northwich, Whitworth, Withington.

III. or IV. Crosby, Melling, Preston, Whalley.

III. Meltham, Stockport, Wardleworth.

The observations are not sufficiently numerous to enable the isoseismal of intensity VI. to be drawn. All the places where the intensity was V. lie, however, within a well-defined curve which is shown upon the map. This curve is approximately circular. Its dimensions are 22 miles from north to south, and 23 miles from east to west. It includes an area of about 396 square miles. Its centre is half a mile west of the village of Bradshaw and two miles N.N.E. of Bolton.

It will be noticed that, at several places within this curve, the intensity is given as only IV. This may be due to one of two causes. (1) The intensity may really have been more than IV., but the rattling of windows, etc., may have been recorded as the most noticeable effect of the shock; or (2) the intensity may have been different at two neighbouring places within this isoseismal, this being only what we should be led to infer from Prof. Milne's seismic survey of Tokio.

Outside this isoseismal, the places where the intensity is known, though numerous, are scattered over a much greater area, and it is not possible to draw with any accuracy the isoseismal of intensity IV. As some of these places are not very distant from the line which I have indicated on the map as the boundary of the disturbed area, we may conclude that that boundary represents an isoseismal of intensity less than IV., but yet greater than III. This area, as before remarked, is nearly circular, and it is almost exactly concentric with the isoseismal of intensity V.

Sound-Phenomena.—Records of sound-phenomena come from 49 out of the 156 places where the shock is known to have been felt. These places are indicated as before by small crosses (+) drawn through the spots representing them.

Referring to the map, it will be seen that, with four exceptions, all the places where sounds are said to have been heard lie within an area which is approximately circular. It is of course possible that, outside this area, the sounds might have been heard by observers who were listening attentively or who happened to be more sensitive to such vibrations. This may have been the case in the four exceptions just referred to, but it should be noted that, at each of these places, we have only one record of sound-phenomena, while at all the other places there are either several independent accounts, or else the description is so clear as to be quite free from doubt. The following are the accounts from these four places:—

Bolton-by-Bowland: a rumbling noise.
Longridge: a noise as of a sough of wind.
Greenhalgh: an underneath rushing rumbling noise.
Marbury: a dull rumbling noise.

Whilst, then, the characteristic earthquake-sounds may have been heard outside the curve marked (by a dotted line) upon the map, I believe that that curve includes all the places where the sounds were distinctly and certainly heard.

Assuming this to be the case, two facts are at once evident from an inspection of the map.

(1) The sounds were not heard so far as the vibrations of longer period were felt. They were confined to a nearly circular district, 29 miles in diameter, and about 636 square miles in area.

(2) The sound-curve is not concentric with the two isoseismal curves drawn upon the map. At its northern limit, it nearly touches the isoseismal of intensity V.; but, at the other end, it passes about six miles to the south-west of this line. Its centre is about $3\frac{1}{4}$ miles S.S.E. of the epicentrum; but this determination cannot be regarded as so accurate as in the case of the Edinburgh earthquake, for it is not checked by a knowledge of places where the sound was certainly not heard.

This second conclusion—the excentricity of the sound-area—is also borne out by the following table. The earthquake-sounds are recorded as having been heard:—

Within the isoseismal of intensity V. at	33 out of	72 places, or in	46 p.c. of the whole.
Between this isoseismal and the sound-curve at	12 „	25 „	48 „
Between the sound-curve and the boundary of the disturbed area at	4 „	41 „	10 „

Throughout the area in which they were heard, the sounds varied greatly both in nature and duration; and, in most cases, the variation seemed to have depended on the position of the place of observation. The exact duration is not often explicitly stated. It is given at about four seconds at Bury, four or five seconds at Chorley, about two seconds at Bacup, several seconds at Altrincham, and a few seconds at Bolton and Middleton. Something may, however, be inferred from the numerous accounts that have been given of the phenomena.

The following descriptions seem to indicate that the sound was more or less sudden and transitory:

(*a*) Cheetham: as of a heavy body falling in the street.
Darwen: (1) closely resembling that made by a door being violently shut; (2) like the fall of a signal-post.
(*b*) Accrington: like the thud caused when snow falls from the roof.
St. Helens: a rumble as of a heavy thud on the gable end of the house.
Tyldesley: as if some heavy weight had fallen in the room below.

In the next group, the sounds were apparently more prolonged:

(*a*) Chorley: like the rumbling of heavy waggons on stone pavement.
Eccles: there was a noise as of very heavy snow sliding down the roof, and as it passed the S.S.W. corner there was a sound as if many tons of snow had fallen on the ground.
Heaton Chapel: resembling a vehicle in the street.
Leyland: such that a cabman thought his horse had run away.
Lower Broughton: like the suppressed roaring of wind entering a gorge.
Manchester: a rustling noise as of wind playing among loose paper.
Moston: a noise attributed to a colliery explosion.
Prestwich: like a heavy but distinct roll of thunder.
Sough: resembling that of a horse which had got loose in its stall.
(*b*) Bacup: like that of a road-engine.
Hulton Park: as if a carriage were driving up to the door.
Leigh: as of heavy waggons rolling rapidly along the street.
Orrell Post: like that of a heavy conveyance passing in the heavy snow which had fallen during the day.

Now, in both lists, all places preceded by the letter (*a*) are situated in the N.W. and S.E. quarters formed by drawing lines from north to south and east to west through the epicentrum; and those preceded by the letter (*b*) are in the N.E. and S.W. quarters. These results are summarized in the following table:

	a.	*b*.	Total.
Sounds of short duration at	2	3	5 places.
Sounds of long duration at	9	4	13 ,,

We may conclude, then, that, on the whole, the duration of the sound was greater at places near the line of the Irwell fault than at places more remote from it.

Miscellaneous phenomena.—As it is somewhat unusual for earthquakes to be felt strongly, if at all, in pits and excavations, it is worth mentioning that the Lancashire earthquake was noticed in mines in several instances. In one of the collieries in the Ince district, near Wigan, the shock was felt so distinctly by a party of men, that a careful inspection was made by them to see if any accident had happened. In the Pendlebury Colliery, "at about 10.30 p.m. the colliers on No. 9, East side, Rams Mine, came out of their working places to the engine-house and reported to the fireman that they had heard a rumbling noise in the roof of the working places." At Agecroft Colliery, "only one man noticed anything. He was in No. 2 pit, and when he heard the sound he went out to the pony road to see if it had been caused by a fall of dirt."[1]

Stonyhurst Observatory is about 19 miles north of Bolton, outside the isoseismal of intensity V., but still some miles within the boundary of the disturbed area. As it seemed possible that the magnetic instruments might have been affected by the earthquake, I wrote to the late Father Perry on the subject. The letter arrived during his last absence from England; and, after his death, Mr. W. C. Cameron was good enough to inform me that no trace of the earthquake was shown by the magnetic curve of February 10. This result is curious, considering that, shortly after several recent earthquakes, magnetic instruments in distant observatories, far beyond the range of the sensible shock, have been perceptibly affected. The cause of these disturbances is not certainly known, but is probably due to the mechanical action of the shock, the masses of the two arms of the instrument being made unequal, in order that it may rest horizontally.[2] If this be the case, the absence of any noticeable disturbance at Stonyhurst may have been due to the fact that the line joining it to the epicentrum of the earthquake is so nearly in the direction of the magnetic meridian.

Position of the Seismic Focus and Geological Relations.—The faults of the Bolton district are, with a few small exceptions, arranged in two systems, one running N.N.W. and S.S.E., and the other nearly E. and W. Prominent among the former series is the great Irwell Valley fault. This important dislocation, which is shown upon the map of the earthquake, has been traced for a distance of more than twenty miles, from near Poynton in Cheshire to about three miles north-west of Bolton. Throughout its whole course the downthrow is towards the north-east. The amount of its throw is considerable, being 1050 yards at Farnworth, about three miles south-east of Bolton.[3]

Now, as we have seen, both isoseismal lines are approximately circular and almost exactly concentric. The centre of the smaller curve (intensity V.), which is the more accurately drawn, is about two miles N.N.E. of Bolton, or half a mile west of Bradshaw; and we may take this point as indicating very nearly the position of the epicentrum, which is therefore close to the intersection of the Irwell fault with the surface, and on the downthrow side of it.

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[1] The last two accounts are quoted from a note read by Mr. J. Knowles before the Manchester Geological Society on March 12, 1889.

[2] Geol. Mag. Dec. III. Vol. II. pp. 210–211.

[3] E. Hull, Geology of the Country round Bolton, Lancashire (Geol. Surv. Mem.).

The centre of the sound-area, as drawn upon the map, lies, however, about 3½ miles S.S.W. of the epicentrum, and therefore to the south-west of the line of the Irwell fault. But since, as before remarked, there may be a slight error in this determination, and since the minor faults of the district are excluded, by their position with respect to the epicentrum, from any relation with the earthquake, I think we may with some probability connect the origin of the earthquake with the Irwell fault.

There is, however, other evidence bearing on the point. (1) It has been shown that, as a general rule, in the neighbourhood of the continuation of the Irwell fault near Bolton, the number of vibrations was greater than elsewhere, and the sound-phenomena were also more lasting; and this is what we should expect if the seismic focus were a plane whose strike is N.W. and S.E. (2) The maximum intensity was recorded at Tottington, about two miles east of the epicentrum, and this, it will be seen, is not far from the point where the perpendicular to the fault-plane through the centre of the seismic focus meets the surface of the earth. Other conditions being the same, it is evident that the intensity should be greatest in the neighbourhood of this point.

The inclination of the Irwell fault near Bolton is 28° from the vertical, according to the horizontal section (sheet 67) of the Geological Survey, which is drawn across the fault. If this inclination be approximately constant to within a few miles from the surface, it follows that the centre of the seismic focus must be at a depth of about 3¾ miles.

Again, as in the case of the Edinburgh earthquake, the movement at four places (Bury, Heywood, Prestwich, and Ramsbottom) on the downthrow side of the fault, was upwards first and then downwards. There are no records of a contrary movement on the upthrow side of the fault; but the evidence, so far as it goes, indicates that the earthquake was probably caused by a slip which slightly increased the throw of the fault.

Lastly, that the distance in a horizontal direction over which the slip extended was very short, may be inferred: (1) from the approximate circularity of the isoseismal lines, and (2) from the short duration of the earthquake-shock and the accompanying sound-phenomena. Since the duration is rarely mentioned as being more than a few seconds, it is possible that this distance was not much greater than a mile.

The whole evidence being taken together, the following conclusions seem to me probable: (1) the Lancashire earthquake was caused by a slip of the Irwell fault, a few miles from its north-western extremity as traced upon the map: (2) the horizontal length of the slip-area was short, possibly less than a mile: (3) the slip resulted in an increase of the throw of the fault: and (4) the slip must have extended upwards to within a short distance from, if not quite up to, the surface, the amount of the slip near the surface being of course extremely small.

Origin of the Sound-phenomena.—The observations on the sounds that accompanied the Edinburgh and Lancashire earthquakes lead to an important result, throwing light on the origin of these vibrations and the part of the focus from which they proceed. I will now point out briefly what I believe to be the origin of these sounds, reserving a more complete discussion of the question for a subsequent paper in which other facts bearing on the problem may be conveniently brought together.

In both earthquakes, the shock and sound, we have reason to believe, were caused by slipping along well-known faults, the foci of the sounds being nearer the surface than the foci of the corresponding shocks. In both, also, the area over which the slip took place must have been very limited in extent: and, while the amount of the slip may have been greatest near the centre of this area, it must certainly have died away towards its upper and lateral margins.

Now, the seismographic records recently obtained by Prof. Milne and others in Japan show that earthquakes usually begin with a series of tremors very small in amplitude and very rapid in period, from six to eight occurring every second, but becoming slower before the shock takes place. These may last for many seconds or even several minutes. Following, and continuous with, them come the sensible vibrations, of larger amplitude and longer period, about three to five occurring in every second. One or more of these, attaining a still greater amplitude and longer period, of one or two seconds each, constitute what are generally known as the principal shock or shocks. The earthquake closes with vibrations of smaller amplitude, but which have a period so long that no record of them can be obtained. The earliest tremors, on the other hand, are not registered on account of the smallness of their amplitude, and, in all probability, as Prof. Milne suggests, the "minute movements which have been recorded are the continuation of still smaller and more rapid movements which . . . . have never yet been rendered visible." It is to these supposed rapid vibrations which form the front portion of an advancing earthquake, that Prof. Milne attributes the origin of the earthquake-sounds.[1] We may conclude from these observations that, initially at any rate, the period of the vibrations increases and decreases with their amplitude.

Now, from different parts of the area over which a fault-slip takes place, there must proceed vibrations differing greatly in amplitude, and therefore also in period. From the central portions of the slip-area will come, as a rule, the vibrations of largest amplitude and longest period; while, from the margins there will proceed minute vibrations of a period so short that they may be perceptible only as sound. The position of the line separating the marginal and central parts of the slip-area will depend only on the amplitude of the vibrations corresponding to the period of the lowest sound that can be heard; it will not at all depend on the amount of the slip at the centre of the area, *i.e.* it will be independent of the *intensity* of the shock.

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[1] Prof. J. Milne, Japan Seismol. Soc. Trans. vol. xii. (1888), pp. 53–62 and 107–8.

I shall endeavour to show, in a later paper, that this theory of the origin of earthquake-sounds accounts satisfactorily for all their phenomena, so far as they are known to us. For the present, it will be sufficient to point out that it explains (1) the fact that the sound-area is not concentric with the disturbed area, and the sound-focus is nearer the surface than the rest of the seismic focus; and (2) the fact that, in great earthquakes, the sounds are only heard within a comparatively small area immediately surrounding the epicentrum.

Authorities.—"Accrington Gazette," Feb. 16; "Accrington Times," Feb. 16; "Altrincham Division Advertiser," Feb. 15; "Blackpool Times," Feb. 13; "Bolton Chronicle," Feb. 16; "Bradford Observer Budget," Feb. 16; "Burnley Express," Feb. 16; "Bury Guardian," Feb. 16; "Chorley Standard," Feb. 16; "Craven Herald" (Skipton), Feb. 16; "Darwen Post," Feb. 16; "Halifax Courier," Feb. 16; "Heywood Advertiser," Feb. 15; "Huddersfield Chronicle," Feb. 16; "Lancaster Guardian," Feb. 16; "Leeds Mercury," Feb. 12; "Leigh Chronicle," Feb. 15; "Liverpool Mercury," Feb. 12; "Macclesfield Chronicle," Feb. 15; "Macclesfield Courier," Feb. 16; "Manchester Examiner," Feb. 12; "Manchester Guardian," Feb. 12, 13; "Middleton Guardian," Feb. 16; "Northwich and Knutsford Chronicle," Feb. 16; "Oldham Standard," Feb. 16; "Preston Guardian," Feb. 16; "Rochdale Observer," Feb. 13, 16; "Wigan Observer," Feb. 13.

Nature, vol. 39, p. 376; T. R. H. Clunn, The earthquake in Lancashire, Nature, vol. 39, p. 390; J. Knowles, The earthquake shock of February 10th, 1889, Manchester Geol. Soc. Trans., vol. xx. pp. 155–157.

For other information I am indebted to the kindness of the following gentlemen: the Secretaries of the Geological Societies of Liverpool and Manchester, Mr. W. C. Carlisle (Stonyhurst Observatory), Mr. B. Hainsworth (Rossall), Mr. G. Hartnup (Liverpool Observatory, Bidstow) Prof. E. Hull, F.R.S., and Mr. Isaac Roberts, F.R.S. (Maghull).

(*To be continued.*)

NOTICES OF MEMOIRS.

On the Young of *Baculites compressus*, Say. By Amos P. Brown. (Proc. Acad. Nat. Sci. Philadelphia.)

At the meeting of the Academy of Natural Sciences of Philadelphia on March 10th, Mr. Amos P. Brown described the young of *Baculites compressus*, Say, recently discovered by him in some Cretaceous marl from the vicinity of Deadwood, South Dakota. Associated with them in the same material were several species of *Baculites*, *Scaphites*, and *Inoceramus*. The young *Baculites* varied in length from 1 to 3 cm., with a diameter of 0·4 to 2 mm.

The shell originates in a spiral consisting of from two to two and one-half slightly overlapping whorls, and ranging in diameter from 0·8 to 1 mm.; thence it extends in a straight line, tangent to the spiral, or sometimes slightly reflexed. The straight portion of the shell rapidly increases in diameter from 0·38 to 0·40 mm. at the spiral, to about 1·5 to 2 mm. at 2 cm. length. Some of the specimens were entire, and showed that the body-chamber occupied about one-half the length of the shell. The siphuncle is eccentric, and was found to lie near the outer margin of the spiral.

The species was determined from an examination of the suture-line which was traced from the simple form of the very young shell, through forms of gradually increasing complexity, up to the typical suture of the adult of *Baculites compressus*, Say.

That this spiral portion should have hitherto escaped observation can be easily accounted for by its small size and fragile character. In all probability it was broken off long before the shell had attained adult size, and is therefore to be met with only in shells which were preserved in their immature condition.

The description is given in the Proceedings of the Academy, 1891, part i. pp. 159–160, and is accompanied by figures of the young *Baculites*, and of a series of their suture-lines showing the gradual development from a comparatively simple form to the typical suture of the adult of *Baculites compressus*, Say.

REVIEWS.

I.—PROFESSOR OSBORN ON THE MOLARS OF THE PERISSODACTYLA.

MANY of our readers are probably acquainted more or less fully with Professor H. F. Osborn's elaborate and interesting researches into the nature of the primitive plan on which the molar teeth of mammals are constructed, summaries of which have appeared from time to time in several English scientific journals. The result of these researches was to show that this primitive type of tooth was of the so-called 'tritubercular' form. It may not be out of place to remind our readers that such a tritubercular tooth in the upper jaw is composed of an inner tubercle, or *protocone*, and of two outer tubercles respectively designated *paracone* and *metacone*. By the addition of a second inner tubercle—the *hypocone*—and of two intermediate ones, known as the *protoconule* and *metaconule*, such a tritubercular molar becomes converted into the sextubercular one occurring in many Ungulates.

Professor Osborn has recently been engaged in investigating how the more complex molars of the specialized Perissodactyles have been evolved from this sextubercular type; the results of this investigation being published in a memoir issued under the auspices of the Museum of Harvard College.[1] Since these results are of considerable morphological importance, and are especially interesting to palæontologists, a short *resumé* of them may be acceptable to our readers. For this purpose Prof. Osborn has been good enough to place at our disposal *clichés* of some of the figures illustrating his memoir; which figures, with some of our own, we reproduce.

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[1] Bull. Mus. Comp. Zool. Harvard Coll. vol. xx. pp. 87, *et seq.* (1890).

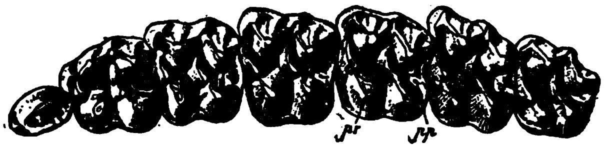

Fig. 1.—Left upper premolar and molar teeth of *Anchitherium* (*Mesohippus*) *bairdi.* *pr.* protocone; *pp.* posterior prominence.

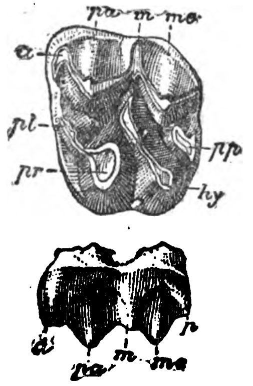

Fig. 2. — Grinding and outer aspects of a left upper molar of *Anchitherium longicriste.* *pr.* protocone; *pa.* paracone; *me.* metacone; *hy.* hypocone; *pl.* protoconule; *a.* anterior ridge; *m.* middle ridge; *p.* posterior ridge; *pp.* posterior prominence.

It may be well to premise our observations by stating that the upper molars of the Perissodactyles are constructed on what is known as the *lophodont* type; this modification consisting of an outer wall, connected with two more or less nearly complete transverse crests inclining backwards. The simplest modification of this type of molar is to be found in the little *Hyracotherium* of the London Clay; but those of the generalized Horse-like animal known as *Anchitherium* (including *Mesohippus*) are but little more advanced. Of this genus we reproduce two of Prof. Osborn's figures; one (Fig. 1) showing the whole series of cheek-teeth, and the other (Fig. 2) a single molar. One species (Fig. 1) is a smaller and simpler form, in which the tubercle marked *pp* is less developed than in the larger species (Fig. 2). In these teeth there is no difficulty in recognizing the six elements of the sextubercular tooth, all of which are indicated by letters in Fig. 2, with the exception of the metaconule, which is the unlettered ridge occupying the middle of the tooth, immediately below the *m.* The four remaining elements, lettered *a. m. p.* and *pp.*, have been developed from the basal cingulum surrounding the molar of *Hyracotherium*; and, accordingly, have nothing whatever to do with the primitive foldings of the crown. This origin is very important with regard to the tubercle marked *pp.* Thus in Fig. 2 this is so strongly marked as to suggest an origin like the other main tubercles; but its commencement as a slight swelling of the cingulum is clearly shown in Fig. 1. To the elements respectively marked *a. m.* and *pp.*, Professor Osborn applies the terms *anterior pillar*, *median pillar*, and *posterior pillar*; stating that the latter term is taken from the writer of this notice, by whom it is said to have been proposed for the teeth of the Horses. To this statement we must take the present opportunity of objecting. The term *posterior pillar* (although it has been subsequently employed by the writer) was first proposed by Prof. Huxley ("Anatomy of Vertebrates," p. 354, 1871), and was applied to the tubercle in the molars of the Horses marked *hy.* in Figs. 3 and 4 (these figures are unfortunately from the opposite side of the jaw to those figured by Prof. Osborn). This tubercle corresponds with the one similarly lettered in Fig. 2 (the hypocone); and has, therefore, nothing whatever to do with the one marked *pp.* Under these circumstances we propose to substitute the term *posterior prominence* for the tubercle *pp.* Again, the term *anterior pillar* was proposed by Prof. Huxley, and adopted by the writer for the tubercle marked *pr.* (the protocone) in Figs. 2, 3; and it is, therefore, quite inadmissible to apply it to *a.* in Fig. 2. Under these circumstances we would suggest that the vertical ridges marked *a. m.* and *p.* in Fig. 2 (which become still more prominent in the teeth of the Horses), should respectively be designated the *anterior ridge, middle ridge,* and *posterior ridge.*

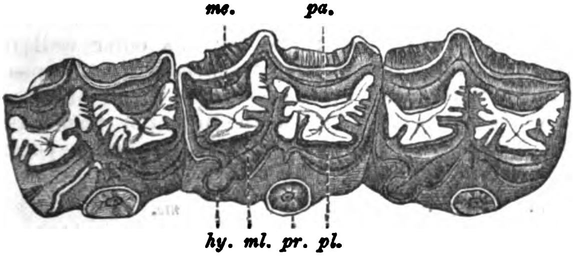

Fig. 3.—Three right upper cheek-teeth of *Hipparion.* *ml.* metaconule; letters as in Fig. 2.

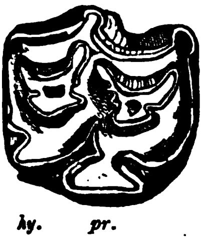

Fig. 4.—Right upper molar of *Equus stenonis*; letters as in Fig. 3.

The figures sufficiently indicate how the equine molar has been evolved from that of *Anchitherium* by the development of one projection from the protoconule to join the metaconule, and of another from the latter connecting it with the posterior prominence, and thus with the metacone; the lengthening of the crown and the filling of the valleys with cement being a concomitant process. The result of this evolution has been to form complete crescents in the equine molar, of which the hinder one is always connected with the hypocone (*hy.*); while the anterior one may either be connected with the protocone (*pr.*), as in *Equus*, or completely isolated, as in *Hipparion.* This has also entailed the division of the median and posterior valleys of the *Anchitherium* molar into an inner and an outer moiety.

The remaining type of Perissodactyle molar we have to notice is that of the Rhinoceroses (Fig. 5). Here Prof. Osborn has introduced three convenient new descriptive terms, which will be equally applicable to the molars of other Perissiodactyles. It appears that the outer wall of the Rhinoceros molar is formed by the union of the primitive paracone (*pa.*) with the metacone (*me.*), to which is added the anterior ridge (*a.*); and for this outer wall the term *ectoloph* is suggested. The anterior transverse crest, formed by the union of the paracone (*pa.*), protoconule (*pl.*), and protocone (*pr.*) is termed the *protoloph*; while for the posterior transverse crest, compounded of the metacone (*me.*), metaconule, and hypocone (*hy.*) we have the name *metaloph.*

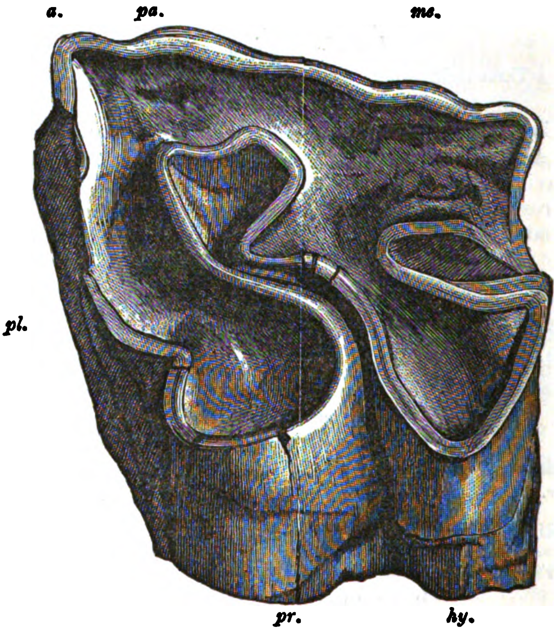

Fig. 5.—Left upper molar of *Rhinoceros palæindicus.* Letters as in Fig. 2. *a.* to *me.* is the ectoloph; *a.* to *pr.* the protoloph; and *me.* to *hy.* the metaloph. The process projecting from the metaloph into the median valley is the crotchet.

In the primitive Rhinoceros molar the three elements—anterior ridge, paracone, and metacone—of the ectoloph are represented by distinct vertical ridges; but some or all of these tend to disappear with the increasing flatness of the outer surface of this part of the tooth as specialization increases. And it is somewhat noteworthy that while in the most specialized types of teeth, like those of the Indian Rhinoceros, of the two African species, and of the extinct Woolly Rhinoceros, the development of the paracone is less marked than in the more generalized Sumatran and Javan species; yet the ridge marking the metacone is decidedly more pronounced. Although there is no distinct representative in the Rhinoceros molar of the median ridge (Fig. 2, *m.*) of the equine tooth, yet we think that this is foreshadowed in the former by the flexure which often occurs in the ectoloph between the para- and meta-cones.

In referring to the secondary enamel-folds which grow from the three compound elements of the Rhinoceros molar into the median valley (the large fissure penetrating Fig. 5 from the inner side), it is to be regretted that Prof. Osborn has again displayed some carelessness in quoting previous work. Thus he states, "These secondary elements consist, first, of three folds projecting into the median valley, one from the ectoloph, the *crista*; one from the protoloph, the *crochet*; one from the metaloph, the *anticrochet*;" his figures being lettered accordingly. Now the fact really is that it is the *crotchet* (as we prefer to spell the word) which projects from the *metaloph*, as shown in Fig. 5, while the *anticrotchet*, when present, is carried by the *protoloph*. The crotchet corresponds, in fact, precisely in position with the projection arising from the protoconule of the protoloph of the equine molar (Figs. 3, 4); and when reaching across to the metaloph divides the median valley into an inner and outer moiety precisely after the equine manner; the only difference being that while in the Rhinoceros the two divisions of the valley remain open, in the Horse they are completely filled with cement. (In Fig. 3 the cement filling the 'island' formed by the outer part of the median valley is drawn white, while that in the outer part of the same—between *pr.* and *ml.*—is made dark and crossed by vertical lines; this difference is owing to the staining of the fossil, but in a recent Horse's both would be pale buff.)

In conclusion, it may be observed that, while it may be convenient in monographs to retain for the description of the molars of the various families of the Perissodactyla the terms commonly in use, yet the importance and interest of being able to trace the precise morphological equivalents of the elements of all these teeth, not only to one another, but also to the primitive type of mammalian tooth-structure, can scarcely be overrated. To a certain degree as regards the former part of this task, and altogether as regards the latter part, zoologists and palæontologists are indebted to the labours of Prof. Osborn. R. LYDEKKER.

II.—GEOLOGICAL SURVEY OF ILLINOIS, A. H. WORTHEN, Director. Volume VIII. GEOLOGY AND PALÆONTOLOGY. Edited by JOSUA LINDAHL, Ph.D., State Geologist. *Geology*, by A. H. WORTHEN. *Palæontology*, by A. H. WORTHEN, CHARLES WACHSMUTH, FRANK SPRINGER, E. O. ULRICH and OLIVER EVERITT. With an Appendix (*Biography, Bibliography* and *General Index* to Volumes I.–VIII.). TEXT. Published by authority of the Legislature of Illinois, July, 1890. 8vo. pp. xiii. 758 and 151, 1 Portrait, 1 Map. Plates I.—LXXVIII. and Explanations, bound in a separate volume.

WITH this massive volume and the Plates accompanying it, the series of Reports on the Geology and Palæontology of Illinois, which have appeared at various intervals since 1866, is finally closed. These Reports, second only in importance to those of the State of New York, have very materially contributed to the advancement of Geological Science on the North American Continent, and they serve as a permanent memorial in honour of Prof. A. H. Worthen, the State Geologist, by whom they have all, with the exception of the closing volume, been edited. To a great extent the present volume was also prepared under his superintendence, but death removed him from his labours, whilst the work was going through the press. The final editing was completed by Dr. J. Lindahl, the successor of Prof. Worthen on the State Survey, and it is very appropriate that a sketch of the life and scientific work of the late Director should have been included in the contents of the final volume. Dr. Lindahl has further contributed a General Index to the entire series, which will prove of considerable assistance to all palæontologists and others who may require to refer to it.

The present volume commences with a chapter on the Drift Deposits of Illinois by Prof. Worthen. From this it appears that they vary in thickness from 10 to 350 feet, and they often extend below the present drainage level of the streams and rivers. The Drift materials are thickest in the central portions of Illinois, they thin out to the south of the State, and, with the exception of the Loess, they all disappear before reaching the Ohio River. The lowest beds consist of stratified sands and clays filling up pre-glacial valleys, over these a layer, 2 to 13 feet thick, of peaty soil filled with plant remains, is usually present. This old soil is covered by Boulder-clays, from 20 to 100 feet in thickness, and these again are partially covered by modified drift and loess containing the bones of *Mastodon*, Mammoth, *Bos*, *Castoroides*, etc. In some places there appears to be a deposit of Boulder-clay material beneath the peaty soil as well as overlying it. The preservation of this soft peaty soil leads Prof. Worthen to the conclusion that the Boulder-clay must have been produced by floating ice rather than by glaciers.

In a second chapter the same author gives the results of numerous borings for coal and in search of natural gas and oil, but though some of the borings have been carried to a depth of over 2300 feet, penetrating nearly to the base of the stratified rocks in the region, no economical results as regards gas and oil have been obtained.

The second part of the volume is devoted to Palæontology, and the first section contains descriptions of fossil Invertebrates by A. H. Worthen. Numerous species of Corals, Crinoids, Molluscs, etc., for the most part from different divisions of the sub-Carboniferous, are treated, but they do not seem of special importance. The discovery of a new species of *Ascoceras*, *A. Southwelli*, from the Niagara Limestone, is of interest.

In section ii. Messrs. Wachsmuth and Springer describe new species of Crinoids and Blastoids from the Lower Carboniferous of Le Grand, Iowa, and from the Niagara Group of West Tennessee. Not infrequently the stems of these Crinoids are preserved intact, and in almost all cases they taper distally to a fine point and give off rootlets or cirrhi in all directions, from which the authors conclude that these and other Palæocrinoids probably lived a semi-free existence, like recent forms of *Pentacrinus*, either anchored by the cirrhi to the soft oozy sea-bottom, or at intervals attached to foreign bodies. The new species belong to the following genera: *Actinocrinus*, *Megistocrinus*, *Dorycrinus*, *Rhodocrinus*, *Platycrinus*, *Dichocrinus*, *Graphiocrinus*, *Scaphiocrinus*, and *Taxocrinus*. A specimen of a new Blastoid, *Orophocrinus fusiformis*, retains a portion of the stem and also the pinnules.

In sections iii. iv. and v. Mr. E. O. Ulrich (in part nominally associated with Mr. O. Everett) treats of American Palæozoic Sponges. The author's study of this group of fossils is evidently limited and imperfect, shown more particularly when he ventures to express opinions of his own as distinct from those procured from the writings of and correspondence with experienced authorities. Thus, for example, he believes that there are homological affinities between some of the new Silurian lithistid sponges described and the Stromatoporoid genus *Actinostroma*! It is generally acknowledged that the correct determination of fossil sponges is beset with special difficulties owing to mineral changes which they have undergone, and those which Mr. Ulrich has attempted to describe are no exceptions to the rule. This fact will, perhaps, account for the extraordinary type of spicule which is figured as characteristic of a proposed new family, the Aspidellidæ (p. 224, fig. 6), in which four smooth simple rays are thrown off in pairs from the ends of what is styled a profoundly elongated node or horizontal central bar!

Of Devonian and Carboniferous forms, the author describes four new genera: *Hystriospongia*, a tetractinellid; *Batospongia*, either a lithistid or a calcisponge; *Belemnospongia*, a monactinellid, but which, if correctly delineated as having acerate spicules connected by short transverse processes, must be quite distinct from this sub-order, and *Syringelasma*, a lithistid. At the lower horizon of the Trenton limestone, at a single locality in Illinois, a considerable number of fossil sponges have been obtained, which retain their outer forms and canal structure, but their original siliceous skeletons have been replaced by calcite. These sponges have been arranged in several new genera, and placed as a distinct lithistid family of the Aspidellidæ on the ground that the form of their spicules differs from that of any previously described sponge. From an examination of some of these forms, we believe their spicular structure is closely similar to that of *Astylospongia* and that they can be included in the Anomocladina family. The two principal genera are *Zittelella* and *Anthaspidella*, which apparently differ only in the fact that the former is simple and the latter compound. The former genus, moreover, seems to be synonymous with the previously described *Steliella*,[1] Hinde, which has been overlooked by the author. Another new genus, *Edriospongia*, seems to be based on a portion of a specimen of *Aspidella*. *Strotospongia* and *Dystactospongia* are included with Calcisponges; but the former of these is almost certainly siliceous; the character of another new genus, *Camarocladia*, is very indefinite.

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[1] Canadian Record of Science, July, 1859, p. 395.

A single Stromatoporoid is placed under *Actinostroma ? Trentonense*, and its minute structure is stated to resemble that of the Aspidellid sponges!

Section vi. treats of Palæozoic Bryozoa, by E. O. Ulrich, and forms by far the most important subject in the volume, occupying 403 pages of text and 49 quarto plates. On this group we can readily recognize that the author is on safer ground than when treating of fossil sponges, for he has thoroughly investigated the microscopic structure of nearly all the American species, and prepared nearly 4000 thin sections for this end. His descriptions and figures furnish an immense addition to our knowledge of the minute structural details of the various forms, and they afford a very striking instance of the advantage to be gained by the systematic microscopic study of all the forms in a single group of organisms. A chapter is devoted to the general and comparative structure of Palæozoic Bryozoa, and the views stated will be generally accepted; some exceptions, however, might be taken to the assertion that the acanthopores were all originally hollow, though it is acknowledged that their summits generally appear solid at the surface. Allied to the acanthopores are the so-called median-tubules, and the hollow structure of these is equally doubtful.

As regards the classification of the Palæozoic Bryozoa, Mr. Ulrich adopts the plan of extreme division, and a great number of new families and genera are introduced on grounds which appear quite insufficient. It is very doubtful if either of the proposed suborders, Trepostomata, Ulrich, and Cryptostomata, Vine, can be logically established; and numerous objections could be taken to many of the family and generic divisions which have been made. That many of the new genera appear to conflict seriously with those already established is only what may be looked for in a work hailing from the United States, and much of this apparent synonymy could probably be avoided by a franker recognition of the characters of the older types and a less hostile attitude towards the authors of these. In spite of these drawbacks the work of Mr. Ulrich on the American fossil Bryozoa merits the warm appreciation of all palæontologists, and affords a safe basis for future students and systematists to build upon.

G. J. H.

III.—CATALOGUE OF THE FOSSIL CEPHALOPODA IN THE BRITISH MUSEUM (NATURAL HISTORY), PART II. CONTAINING THE REMAINDER OF THE NAUTILOIDEA. By ARTHUR H. FOORD, F.G.S. (London, 1891.) Printed by order of the Trustees, and sold by Kegan Paul, Trench, Trübner & Co. 8vo. pp. xxviii. and 408, with a large folding Table and 86 Woodcuts.

WE gladly welcome Part II. of Mr. Foord's Catalogue of the Fossil Cephalopoda in the British Museum (Natural History). Two years have elapsed since the completion of Part I., containing part of the suborder *Nautiloidea*, consisting of the families *Ortho-*

ceratidæ, Endoceratidæ, Actinoceratidæ, Gomphoceratidæ, Ascoceratidæ, Poterioceratidæ, and *Cyrtoceratidæ.* The present volume contains the remainder of the *Nautiloidea*, consisting of the families *Lituitidæ, Trochoceratidæ,* and *Nautilidæ.* The family *Bactritidæ* was inserted by the author in the Table of the Nautiloidea which he gave in his Introduction to Part I., but in the Introduction to Part II. he states, "On reconsidering the question of the affinities of *Bactrites* (the sole representative of the family *Bactritidæ*), in the light of the investigations of Branco and Hyatt, I am now prepared to accept the systematic position assigned to it by those authors—that is, at the commencement of the Ammonoidea. *Bactrites* will therefore be dealt with in Part III. instead of in this volume."

From a Table appended to the Introduction giving the "Distribution of Genera and Subgenera of Nautiloidea described in Parts I. and II. of the present Catalogue, with the number of species assigned to each," it is seen that there are in the Museum 573 species included in the Nautiloidea, 459 of which are Palæozoic, 93 Mesozoic, and 21 Cainozoic. The Palæozoic species are distributed in 29 genera and 6 subgenera, the Mesozoic in 4 genera and 2 subgenera, and the Cainozoic in 2 genera and 1 subgenus.

The author commences the present volume with the Lituitidæ, which family includes the genera *Lituites, Ophidioceras,* and *Ancistroceras*; the last-named genus does not appear to be represented in the National Collection. The first is represented by the well-known *L. lituus* from the Orthoceras limestone of Sweden, and possibly by one British species. To the genus *Lituites*, J. de Carle Sowerby referred several British species which he described in Murchison's 'Silurian System.' Prof. Blake, in his Monograph of the British Fossil Cephalopoda, Part I., retained in this genus only one of these species, viz. *ibex*, and associated with it in the same genus, though with a query, some specimens which he identified with *Trochoceras arietinum* of Barrande. Mr. Foord replaces this latter species in *Trochoceras*, and refers the *ibex* of J. de C. Sowerby to *Lituites* with a query, remarking that "the presence of *Lituites* in the British rocks must, for the present, be considered as very far from satisfactorily determined."

Ophidioceras, which is known only in the Silurian of England and Bohemia, was regarded by its founder Barrande as a subgenus of *Lituites*, but Prof. Blake regards it as a distinct genus only "remotely related" to *Lituites*, while Hyatt places it near to *Ascoceras.* Mr. Foord considers it to be a distinct genus "whose alliance seems to be clearly with *Lituites*."

In *Trochoceras*, the genus representing the *Trochoceratidæ*, and ranging from the Cambrian to the Devonian, the author describes two new Silurian species, each founded upon a single specimen. The one, *Trochoceras boreale*, collected by Captain Inglefield in the Silurian rocks at Wellington Channel, Arctic America, is a smooth species, and is stated to be "much larger than any of those of the Niagara rocks of North America that come at all near to it." The other, from the Woolhope Limestone, at Hay-Head, East of Walsall, Staffordshire, is a distinctly ribbed species most nearly allied to *Trochoceras mirandum*, Barrande.

In Vol. I. of the Palæontology of New York, Hall described and figured under the name *Lituites undatus* specimens which, according to Mr. Foord, belong to two distinct genera. Prof. Hyatt referred them to the genus *Trocholites*, but Mr. Foord considers that some belong to the genus *Trochoceras*, and to these he has given the name *Trochoceras Halli*.

By far the greater part of the volume is occupied by the *Nautilidæ*, the following genera and subgenera being treated of:—

Trocholites, Conrad.
Gyroceras, de Koninck.
    Subgenus *Aipoceras*, Hyatt.
    Subgenus *Trigonoceras*, M'Coy.
Hercoceras, Barrande.
Barrandeoceras, Hyatt.
Discites, M'Coy.
    Subgenus *Phacoceras*, Hyatt.
Ephippioceras, Hyatt.
Cœlonautilus, Foord.
Pleuronautilus, Mojsisovics.
Temnocheilus, M'Coy.
    Subgenus *Centroceras*, Hyatt.
Solenocheilus, Meek and Worthen, emend. Hyatt.
Nautilus, Breyn.
    Subgenus *Hercoglossa*, Conrad, emend. Meek.
    Subgenus *Clydonautilus*, Mojsisovics.
Aturia, Bronn.

No new species is added to the genus *Trocholites*, but a new species of *Gyroceras*, "closely allied to *Gyroceras ornatissimum*, de Koninck, sp.," is described from the Carboniferous Limestone of Ireland under the name *Gyroceras hibernicum*, and upon a single specimen from the same horizon and locality is founded a new species of the subgenus *Aipoceras*, viz. *A. compressum*.

Prof. Hyatt included in Barrande's genus *Hercoceras* such forms as *Gyroceras alatum*, Barr., and *Trochoceras flexum*, Barr., in which the apertures are not contracted, but Mr. Foord restricts the genus to species which have the aperture peculiarly contracted, as in *Hercoceras mirum*, Barr., thereby retaining *H. mirum* (with its variety *irregulare*) as the only known species of the genus.

In addition to the two well-known British species, which fall into the genus *Ephippioceras*, viz. *Nautilus clitellarius*, J. de C. Sowerby, from the Coal Measures of Shropshire and Worcestershire, and *Nautilus bilobatus*, J. Sowerby, from the Calciferous Sandstone of Closeburn, Dumfriesshire, the author describes under the name *costatum* a new species, which occurs in association with *N. clitellarius*.

The name *Cœlonautilus* is comparatively new. The first mention of it seems to be in an exceedingly interesting paper which appeared in the Geological Magazine for November, 1889 (p. 494), by A. H. Foord and G. C. Crick, "On the Shell-muscles of *Cœlonautilus cariniferus*, J. de C. Sowerby, sp.," in a footnote to which paper it is stated that "this name from κοῖλον, hollow (referring to the umbilicus), and *Nautilus*, is proposed by one of us in substitution for *Trematodiscus*, Meek and Worthen, which was used by Häckel for a genus of Radiolarians. The name *Trematoceras* proposed by Hyatt (Proc. Boston Soc. Nat. Hist. 1883, vol. xxii. footnote, p. 291) in lieu of *Trematodiscus* is equally ineligible, because preoccupied; for although the species described by Eichwald (Leth. Rossica, 1860, vol. i. p. 1259)—*Trematoceras discors*—was a *Bactrites*, a generic name once published cannot be again employed, even for a different group, without risk of confusion." Prof. Hyatt retains for the shells comprised in the present group the name *Vestinautilus* proposed by Ryckholt; but de Koninck pointed out that this name was evidently founded upon an error of observation, and since it "cannot be used in the sense intended by its author," Mr. Foord agrees with de Koninck in treating Ryckholt's name as a synonym. Mr. Foord reproduces the figures of the impression of the shell-muscles of *Cœlonautilus*, which appeared in the GEOLOGICAL MAGAZINE for November, 1889, and it is to be hoped that his examination of the large number of specimens of Ammonoidea contained in the National Collection will enable him to demonstrate also the form of the muscular impression in some of the Ammonites. Several new species of *Cœlonautilus* are described, as well as of the genera *Temnocheilus* and *Solenocheilus*.

Then follows the genus *Nautilus*, of which, according to a table given by the author in his Introduction, the Museum contains 88 species, viz. 5 Triassic, 30 Jurassic, 40 Cretaceous, and 13 Tertiary. Mr. Foord remarks: "It might perhaps have been supposed that a genus so rich in species as *Nautilus* is would have supplied many subdivisions or groups of species; but after carefully considering the matter, I have come to the conclusion that such groups are in the present case unnecessary, first, because the relationship in which the species stand to each other is fully set forth in the remarks appended to the descriptions of the species, and, secondly, because such groups are apt to become very artificial, owing to the necessity for frequent change in the selection of the characters upon which they rest. It is true that there are often met with in the genus *Nautilus* assemblages of species having many characters in common, which are, however, too variable to found genera upon."

Many of the species of *Nautilus* are comparatively new, having been described by the author and Mr. G. C. Crick in the Annals and Magazine of Natural History for April and May, 1890; some are quite new, but the excellent figures which accompany the descriptions of these species will greatly facilitate their identification.

It is to be regretted that the whereabouts of some of Sowerby's type-specimens is unknown. This is the case with *Nautilus simplex*. On comparing the characters given by Sowerby with Mr. Foord's description of his new species *semiundatus*, we think the author has good grounds for suggesting the possibility of Sowerby's specimen being a badly-preserved example of this new species. He adds (p. 285), "Unfortunately, the siphuncle has not been seen in *N. semiundatus*, and therefore it cannot be invoked in aid of this comparison." Doubtless he meant to have said that the siphuncle has not been seen in the adult stage, for in his description of *semiundatus* (p. 280) he observes, "The siphuncle in a young individual (No. 36603), 1¾ inches in length, is very near the inner (dorsal) margin of the septa." The position of the siphuncle then, so far as it is known, constitutes another point of agreement with Sowerby's *N. simplex*.

As the author has not been able with abundant material before him to determine to what maturer form Sowerby's small specimen of *N. inæqualis* belongs, we quite agree with him that it is much better to drop the name altogether. The specific determination of very young Nautili is often absolutely impossible.

Passing on to the genus *Aturia* we notice, that while Edwards in his Monograph of the Eocene Mollusca (Pal. Soc. 1849) described and figured two varieties of the well-known *Aturia ziczac*, Mr. Foord reserves this name for the form figured by J. Sowerby in plate i. of his Mineral Conchology, and gives a new name, *A. Charlesworthi*, to the more compressed shell which Edwards distinguished as var. *β*. The latter comes very near to the Dax shells *Aturia Aturi*, Basterot, but the differences in the suture-line and the amount of compression are considered sufficient to justify the separation of the species. As to the *Nautilus lingulatus*, v. Buch, from the Eocene of Kressenberg, Bavaria, Mr. Foord concurs with Dr. Geinitz in referring it to *Aturia ziczac*, J. Sowerby, sp.

The concluding section on the *Nautilidæ* deals with the Rhyncholites or the mandibles of fossil Nautiloids. Various names have been given to these fossils, and various opinions have been entertained as to the advisability of referring them to genera and species. Although it has been suggested that Rhyncholites may be of more importance for the purpose of classification than the guards of Belemnites, Mr. Foord refrains from referring them to genera and species, (1) owing "to the want of stable characters upon which to found genera and species," and (2) because the material is not "sufficiently abundant to enable one to trace the variations that may arise in different stages of growth, and thus to afford data for the limitation of such species as may be constituted," and he adds, "Under these circumstances I have merely figured some of the principal types of the fossil beaks met with in the Jurassic and Cretaceous rocks of England which, so far as I am aware, have not been illustrated." The figures are exceedingly good, and in addition to the fossil beaks the author gives some admirable figures of the upper and lower mandibles of the recent Nautilus (*Nautilus pompilius*).

Dr. K. A. von Zittel, writing in 1884 (Handb. d. Palæont. Band II. p. 386), states that hitherto lower mandibles have been found only in the Muschelkalk. Mr. Foord's examination of the National Collection has, however, enabled him to record and figure specimens from the Lias of Lyme Regis and the Lower Chalk of Dover.

The Rhyncholites are so rarely associated with the Cephalopod to which they belong, that the specimens of *Nautilus Libanoticus* in the Museum that the author states have one or other of the mandibles *in situ* must be regarded as treasures indeed. A figure of one of these specimens is given, showing the mandible upon the surface of the cast of the ventral aspect of the body-chamber.

The figures in the book are both numerous and excellent, and we feel quite sure that the volume will prove a most valuable addition to our knowledge of the Cephalopoda.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 27, 1891.—Sir A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

The Secretary announced the presentation by Sir John W. Dawson, LL.D., F.R.S., of a series of photographs of Nova-Scotian Coal-Measure Amphibia and Reptilia, and read an explanatory note written by the donor.

Dr. G. J. Hinde remarked that additional interest attached to the genus *Hylonomus* from the fact that a representative of it had lately been discovered in the Burnley Coalfield, and described by Mr. A. Smith Woodward, F.G.S., in the May Number of the Geological Magazine under the name of *Hylonomus Wildi.*

1. "On the Lower Jaws of *Procoptodon.*" By R. Lydekker, Esq., B.A., F.G.S.

After reviewing Sir R. Owen's writings upon the large extinct Kangaroos for which he established the genus *Procoptodon* in 1874, the author describes two mandibular rami from the clay beds of Miall Creek in the neighbourhood of Bingera, N.S.W., which belong to this genus, and from their characters and a comparison of them with the lower jaws in the British Museum, he maintains that this part of the skull indicates two very distinct species of the genus, for which he retains the names *P. rapha*, Ow., and *P. goliah*, Ow., though it is possible that the types of those two species are really specifically identical, in which case the name *P. pusio*, Ow., might have to be adopted for one of the species described.

2. "On some recently exposed Sections in the Glacial Deposits at Hendon." By Henry Hicks, M.D., F.R.S., Sec. Geol. Soc.

In this paper the author brings forward evidence obtained from sections exposed in gravel-pits and deep cuttings made for the purpose of laying down the main sewers, to show that Glacial Deposits had been spread out to a much wider extent over the Hendon plateau than had hitherto been supposed, and that they had reached down the slopes to below the ordnance-datum line of 2000 feet. He further mentions that there is evidence to show that these deposits have extended in a S. and S.W. direction across the Brent and Silk Valleys, and now occur on most of the heights in the parishes of Kingsbury and Willesden. As the sands, gravels, and Boulder-clay which cover the Hendon plateau and the neighbouring heights are found to rest on an undulating floor of London Clay, and to follow the contours of the hills and valleys, the author considers that it is clear that the main physical features of this portion of N.W. Middlesex were moulded at a very early stage in the Glacial period, and before the so-called Middle sands and gravels and overlying Upper Boulder-clay with Northern erratics, were deposited. He believes that at this time there could have been no barrier of any importance to prevent these deposits from extending into the Thames Valley, and that the evidence clearly points to the conclusion that the implement-bearing deposits on the higher horizons in the Thames Valley should be classed as of contemporaneous age with the undoubted glacial deposits at Hendon, Finchley, and on the slopes of the Brent Valley, which they so closely resemble. The author is therefore satisfied that man lived in the neighbourhood of the Thames Valley in the early part of the Glacial period; probably, he thinks, in pre-Glacial times.

CORRESPONDENCE.

CORRELATION OF QUATERNARY CHANGES OF LEVELS IN NORTH AMERICA AND THE CARIBBEAN REGION.

SIR,—Referring to Mr. Jukes-Browne's letter in this MAGAZINE for March (p. 143), and to his and my preceding articles and correspondence therein cited, I have to reply that the questions which he asks are manifestly very difficult; but certain points may be noted which partially answer them. If the end of the Tertiary era and beginning of the Quaternary were characterized by elevation of the greater part of the North American continent to such altitude as to give a much cooler climate, and by a contemporaneous depression of the West Indies and the Isthmus of Panama, allowing a large part of the equatorial Atlantic current to pass into the Pacific Ocean, the result of these combined conditions being the accumulation of the ice-sheets of North America and Europe, we should expect to find west of the Gulf of Mexico, as Mr. Jukes-Browne suggests, evidences of recent changes of levels. The subsequent depression of the continent north of the Gulf and the uplift of the West Indies and the Panama region, bringing the present relative heights of land and sea, may have produced the east to west line of fissuring and faulting which crosses Mexico near 19° north latitude, shown by the very remarkable series of volcanoes of Tuxtla, Orizaba, Popocatepetl, Ixtaccihuatl, Toluca, Jorullo, and Colima. Farther west, this line of disturbance in the earth's crust probably extends to the volcanic Revillagigedo Islands. Eastward, after crossing the base of Yucatan, it appears to be represented by the Great and Little Cayman Islands, and by the Sierra Maestra on the south shore of eastern Cuba, with the contiguous "Bartlett Deep," a very profound narrow trough of the Caribbean Sea, reaching from Honduras Bay to the Windward Passage; and thence the same orographic belt is continued by Santo Domingo, Porto Rico, and the Windward Islands, with the very deep oceanic troughs north, south, and south-east of Porto Rico (bathymetric map of the Caribbean region, A. Agassiz, Three Cruises of the "Blake," vol. i. fig. 57).

The disturbances along this belt, however, have been of a different order from the uplifts and subsidences which have affected the whole continental area northward from the Gulf of Mexico, as known by the Pleistocene submergence of river valleys and fjords on the Atlantic, Pacific, and Arctic shores of North America. No less than twenty submerged valleys, some of them extending to depths of 2000 to 3000 feet, have been found by soundings on the coast of California by Prof. George Davidson, of the U.S. Coast Survey; and Prof. Joseph Le Conte has shown that the time of elevation during which they were eroded was the Pliocene and early Quaternary, which also included the plication of the Coast Range, the outpouring of the lavas forming the Cascade Range, and the faulting and tilting that elevated the Sierra Nevada, Wahsatch, and Basin Ranges to their present height (Elements of Geology, new ed. 1891; Bulletin G.S.A. vol. ii. 1891, pp. 323–330). On the Atlantic coast, too, the submerged valleys mentioned in previous articles were doubtless eroded during the same time. Excellent evidence of this is given by the submarine channel of the Hudson, partly a profound fjord, extending about 100 miles beneath the sea, and descending to the depth of 2844 feet; for samples of its bottom and banks, brought up by the sounding-lead, appear to belong to a continuation of the Tertiary sandy clays of New Jersey (Am. Jour. Sci. III. vol. xxix. pp. 475–480, June, 1885; vol. xl. pp. 425–437, Dec. 1890, with map). These deeply submerged, narrow river channels, and the similar Arctic fjords, together bear testimony of a late Tertiary and early Quaternary elevation of nearly all of North America to such altitude that the resulting colder climate would induce glaciation. So widely extended continental uplifting, and the later Pleistocene depression of the same area, belong to a class of the earth's crustal movements which Gilbert and White have called epirogenic, that is, continent-making, in contrast with orogenic or mountain-making upheaval and subsidence.

In the Caribbean region depressions succeeded by elevation during the Quaternary era, which are known from the raised coral reefs studied by Mr. Jukes-Browne and others, belong to orogenic movements, chiefly by faulting, uplifting, and tilting, which have taken place on a most grand scale in this era throughout the chain of the West Indies and Windward Islands, and along the entire Cordilleran belt from Cape Horn to Panama, to the Sierra Nevada and Great Basin, and to Mount St. Elias and the Aleutian Islands. These mountain-making disturbances have been closely related with the great epirogenic uplift and depression of North America, and with their duplication in two distinct Glacial epochs, divided by a very long interglacial epoch on this continent; but to attempt discussion of details of their correlation, or to speculate upon the condition of the earth's crust and interior permitting such changes of levels, would require too much space for a letter. Some notice of these matters will be found, respectively, in my article in the American Journal of Science for January, 1891, and in my appendix of Wright's "Ice Age in North America."

SOMERVILLE, MASS., *April 6th*, 1891. **WARREN UPHAM.**

A VARIETY OF PICRITE (SCYELITE) IN SARK.

SIR,—Rather more than two years since (Dec. III. Vol. VI. p. 109) I wrote a description of a variety of Picrite which I had found in boulders at Port du Moulin, Sark, stating that I published it, as there was "no probability of my returning to Sark for years, if ever," in the hope some one would trace this interesting rock to its home. But the unexpected often happens: last summer's work among the hornblende schists of the Lizard determined Mr. Hill and myself to re-examine those of Sark, and in the process of this the picrite was not forgotten. After a careful search along the rocks at low water we found a dyke of this rock at the foot of the cliffs between Port du Moulin and Saignie Bay, nearly opposite to (perhaps rather to the south of) the Grand Autelet. It is at the base of a little spur from the cliff of banded gneiss, into which it is intrusive, but it only shows for a foot or so above the shingle, in two or three humps, running seawards. In this direction, about fifteen yards off among the boulders, is another boss. I have examined the rock under the microscope. The olivine is not so well preserved, there is rather less mica and more hornblende than in the specimen described in 1889; it is not quite so obviously connected with the serpentines, but I have no doubt that the boulder came from some part of this dyke. We searched the cliffs very carefully up to the further side of Saignie Bay on the north, and for some distance to the south of Port du Moulin without finding any other dyke. We now think it very improbable that Ansted, in speaking of a dyke of serpentine as crossing the island, referred to this rock. We reserve further particulars for a paper in which we hope to communicate to the Geological Society the result of our work in Sark.

T. G. BONNEY.

OBITUARY.

PETER MARTIN DUNCAN,

M.B. (LOND.), F.R.S., F.G.S., F.L.S., ETC.

BORN, 20TH APRIL, 1824. DIED, 28TH MAY, 1891.

PETER MARTIN DUNCAN was born at Twickenham in 1824, and received most of his early education in the Grammar School there. After leaving this he lived for a short time in a school in Switzerland, and on his return to England entered the Medical Department of King's College, in September, 1842. He there received the whole of his formal scientific training; he passed the preliminary M.B. examination with honours in Anatomy and Physiology in 1844, and obtained the full degree in 1846; he was elected an Associate of his College in 1849. Upon the conclusion of his medical studies, he acted for a time as assistant to a doctor at Rochester, whence he removed to Colchester, where a practice had been purchased for him. Here he remained for many years, and it was during this period that he published his first scientific essay, which consisted of "Observations on the Pollen tube, its growth, histology and physiology" (1856). But he did not at Colchester secure much time for original research, for most of that which was left him by his profession was occupied by work in connexion with the municipal politics of the borough, in which he seems to have played a prominent part. The fact that he served as Mayor shows that he had won the confidence of his fellow-townsmen, while the admirable arrangement of the local Museum, which under his direction was reorganized upon lines far in advance of the time, is a sign of his interest in the educational institutions of the town. After his return to London to a practice at Blackheath, he was able to spare more time for scientific work, specializing upon the Corals; and as his interest deepened in the problems which these presented him, he was led to abandon lucrative prospects in his profession and devote himself entirely to original research. In this he was no doubt encouraged by the reception accorded to his first palæontological papers, which were read in 1863; they at once gained him recognition as one of the ablest of British palæontologists; he was in the following year appointed one of the Honorary Secretaries of the Geological Society, and two years later he was elected F.R.S.

After leaving Blackheath he settled near Regent's Park, but he was not long allowed to remain in retirement, as in 1870 he was called to the chair of Geology at King's College, and a Fellowship followed in the next year. Shortly afterwards he accepted also the Professorship of Geology at Cooper's Hill, and he held both appointments till his death. He resigned the Secretaryship of the Geological Society in 1870 after a seven years' tenure of office through a period in which the change of apartments had made the duties more than usually onerous. In 1872 he was elected one of the Vice-Presidents, an office which he held till his promotion to the Presidency in 1876 and 1877. In 1881 he was awarded the Wollaston Medal, the highest honour which the Geological Society can bestow. Though it was the Geological Society with which he was most closely connected, he was an influential member of other scientific bodies; he served on the Council of the Royal Society from 1876 to 1878, was President of the Geological Section of the British Association in 1879, and of the Microscopical Society from 1881 till 1883. By his resignation of this post he terminated an official career of no ordinary usefulness, and retired to Gunnersbury, where he passed the remaining years of his life.

On turning to Prof. Duncan's scientific work, one is impressed by the enormous amount he accomplished and the wide range of his interests and influence. As has been previously remarked, his first paper (1856) was botanical, and he long retained his interest in the subject, his last paper on vegetable physiology being published in 1874; while still later he worked out the parasitic algæ which he discovered in some of his Silurian Corals. His first important work was the series of five memoirs on the Fossil Corals of the West Indies, a subject which he took up, as at that time he failed to get the necessary facilities for the study of the recent forms. The subject was full of difficulty; the living Corals of the area were but little known, so that the materials for the comparison of the recent and fossil faunas were quite insufficient. But Prof. Duncan attacked the subject with characteristic energy, and his sound common sense enabled him to avoid many a pitfall; his memoir was certainly a most valuable addition to the knowledge of the later Tertiary Corals. This work was followed by a long list of papers and monographs in which he described the Coral faunas (especially the Cainozoic) of England, Australia, Tasmania, India, Java, Arabia, and Malta. His "British Fossil Corals" is probably one of the finest contributions to English Palæontology ever published by the Palæontographical Society; it was so much more modern in its methods and more thorough in its treatment than the less painstaking work to which it was issued as a Supplement.

But though Prof. Duncan's interests were probably at first rather zoological than geological, he soon became absorbed in the line of work which he had been led by circumstances to select. He early realized that the description of the anatomical structure and the determination of the systematic position of a fossil did not constitute the sole duties of a palæontologist. With him these were but preliminary to the consideration of the affinities of faunas and their bearing on the physical geography of the past. He was a palæontologist in the truest sense of the word,—not a morphologist who happened to study extinct forms, but a geologist who used fossils as a petrologist uses minerals. Hence his early work on the West Indian Corals commenced by a detailed study of their conditions of fossilization and closed by a discussion of their evidence as to the Cainozoic physiography of the Caribbean region; similarly his later studies of the European Corals led to his striking paper on "The Physical Geography of Western Europe during the Mesozoic and Cainozoic periods elucidated by their Coral Faunas."

It was probably his desire to check the conclusions yielded by the Corals that led him to take up also the study of the Echinoidea, and as work with these is more definite than with the former, it yielded him some of his most interesting conclusions. He commenced with the Echinoids of beds, the Corals of which he had already studied; among the most remarkable were the collections from South Australia, which he described in a series of papers dating from 1864 to 1887. It was apparently his interest in the origin of this fauna, with its mixture of Cretaceous and Cainozoic genera, that led him to turn with such zest to the Indian Echinoids, which, in conjunction with Mr. Sladen, he monographed with great detail and care.

Of the Mesozoic Echinoidea he studied with especial interest those of the Cenomanian, and by the aid of the small collections of the Rev. W. F. Holland, in Sinai, and Dr. Carter, in South Arabia, he gradually built up the connexion of the European fauna with that of Northern India. And then, by his comparison of those of the Peninsular and Extra-Peninsular areas, he demonstrated the existence of the land barrier that stretched across India and away to the south-west, of which such important use has been made in recent controversy. His views on geographical distribution were original and had been carefully matured; his lecture on "The Formation of the Main Land Masses" showed that he did not accept the view of the permanence of oceans and continents, a subject upon which his opinion was of especial value. Another of his contributions to chorology was his paper on the fauna of the Alpine Lakes, perhaps the most serious blow ever struck at the theory of the Glacial origin of the Swiss lake-basins.

But though Professor Duncan did not regard morphology as the highest end, he did not by any means neglect it; thus our knowledge of the perignathic girdle of the Echinoids and its value in classification we owe mainly to him; while his remarkably suggestive and original essay on the structure of the ambulacra of the regular Echinoidea, perhaps his most masterly piece of work, has gained the highest praise from men prejudiced against him.

But in addition to his contributions to palæontology he has done much in zoology: he wrote a series of papers on the anatomy of the Temnopleuridæ, Saleniidæ, and other groups of the Echinoidea, and described, amongst others, the Madreporaria of the *Porcupine* Expedition, the Ophiuroids and Corals of Mergui, and in conjunction with his constant collaborator, Mr. Sladen, the Echinodermata from Greenland. It was probably his close study of the recent forms that made his judgment usually so sound, while the knowledge gained was indispensable for the preparation of his two invaluable works "The Revision of the Madreporaria" and his "Revision of the Genera and Great Groups of the Echinoidea." The former was issued in 1885, and consisted of diagnoses of every genus of Corals (excluding Rugosa) and of a classification which has not yet been supplanted. His Revision of the Echinoidea was perhaps still finer, and made a great advance in our knowledge of every order. The application of his own discoveries on the ambulacral structure enabled him to bring the Palechinoidea from chaos into order, and to replace the artificial arrangement of the Diadematidæ by a natural classification; his previous detection of the fundamental differences between the pits of *Temnopleurus* and the fossettes of *Temnechinus* gave him the clue to the arrangement of that group; and his substitution of positive for comparative diagnoses in many recent genera has greatly aided the comparison of the fossil and deep-sea types. But his use of the perignathic girdles in another order was less successful, while his acceptance of Lovén's results brought him into conflict with some continental palæontologists regarding the classification of the Spatangoidea. By these two Revisions alone Prof. Duncan has earned the gratitude of every palæontologist and zoologist; they precisely formulated the best current thought of their time, and have given a firm basis for future work. They must be indispensable works of reference to every student of these groups, till in years to come the progress which they have so largely aided has rendered necessary a new revision, and until some one is then ready and able to undertake the enormous labour such a task involves.

But in addition to the Corals and Echinodermata, Prof. Duncan made some contributions to the study of the Protozoa and Sponges, while his clearness as a teacher led him to undertake a good deal of lecturing and popular literary work; thus he edited the six volumes of "Cassell's Natural History," and amongst others wrote a primer of physical geography, a volume of biographies of the "Heroes of Science," a paper on Voltaire's attitude to geology, and edited recent issues of Lyell's "Students' Elements."

In the course of so much, and such widely different work, it was but natural that Professor Duncan should at times have come into conflict with his fellow-workers, however much he himself detested controversy. On the one hand, his passionate love of justice led him to accept the names of the pioneers of systematic zoology, and thus his nomenclature has been in places rejected by the younger school. On the other hand, his work has been severely criticized by men who, caring for none of the physiographical problems Prof. Duncan set himself to solve, expected him always to unite the detailed precision of an histologist with the grasp of a palæontologist. But at the time of his work on the West Indian Corals, for example, such investigations would not have aided him in his comparison of the recent and fossil faunas; and later opinion seems far more in agreement with his work than with that of the elaborate monographs of Michelotti and Duchaissang that immediately followed his. But it is to be regretted that he did not adopt some modern methods quite as early as he might have done, especially as his work on the *Temnopleuridæ* shows how well he knew how to use them. Another source of trouble was that he had a somewhat aggravating way of giving wrong references, which brought down upon him the censures of those who seem to think that it is a mere matter of detail whether the species be rightly identified so long as the reference be correctly cited. But, loathing controversy as he did, he ignored criticism as far as possible, and perhaps the only time when he was really roused to wrath was by the neglect by some recent Echinologists of the results of the work of his great Swedish friend; the vigour of his onslaught on this occasion puzzled those who did not understand his devotion to the man to whom he often referred with modest reverence as "my master Lovén."

To his first love, the Corals, he proposed to return on the conclusion of his revision of the Echinoidea; he commenced work upon a large Indian collection, and planned a supplement to his Revision of the Madreporaria in which he intended to discuss recent criticism and incorporate subsequent progress. But it was not to be: he was smitten with disease, and after a long and painful illness quietly passed away on the early morning of the 28th of May.

The fine keen sense of humour which remained unblunted almost to the last, the genial kindness with which he was ever ready with help especially to younger men, united with the recognition of his sterling worth and sound judgment, gained for him wide popularity and esteem. And now that Prof. Duncan has passed to his well-earned rest not only is the world the poorer by the loss of a great palæontologist and of a strong and original intellect, but a wide circle of his fellow-workers have to mourn the departure of a trusted friend. J. W. G.

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ORIGINAL ARTICLES.

I.—On the Sands and Gravels Intercalated in the Boulder-clay.

By G. W. Bulman, M.A., B.Sc., Corbridge-on-Tyne.

THE interpretation of the sands and gravels intercalated in the glacial drift is one of the most interesting problems in glacial geology. Do they, on the one hand, represent the deposits of one or more mild intervals alternating with periods of intense cold; or were they, on the other, laid down during one continuous cold period marked by such slight oscillations as can be shown to occur in connection with existing glaciers and ice-sheets?

The former view has been ably advocated by geologists of repute—notably by Prof. J. Geikie—and implies the belief in one or more intervals of mild climate, each comparable in duration to the cold period which it followed and preceded. It is founded partly on the idea that the sands and gravels are due to such aqueous action as would indicate a permanent retreat of the ice; and partly on some few mammalian and other remains found in them.

Prof. Geikie expresses his opinion as follows:—

1. "The till itself is a truly glacial deposit, due to the grinding action over the surface of the country of immense masses of glacier ice. But no one will doubt that its intercalated and subjacent beds of silt, sand, and gravel have had a very different origin. They occur in such layers as could only have been spread out by the action of running water."[1]

2. "We have found that there is abundant proof to show that the accumulation of a *moraine profonde* by one great ice-sheet was interrupted several times; that the ice-sheet vanished from the low grounds, and even from many of the upland valleys, and that rivers and lakes then appeared where before all had been ice and snow. We have also learned that during such mild interglacial periods, Oxen, Deer, Horses, Mammoths, Reindeer, and no doubt other animals besides these occupied the land."[2]

But, admitting such evidence, it is obvious that there must have been not one but several such mild interglacial periods. And so we find Prof. Geikie stating, in his address to the Geological Section of the British Association at Newcastle in 1889, that, "In some places three or more such boulder-clays have been observed overlying one another throughout considerable areas, and these clays are described as being distinctly separate and distinguishable the one from the other." And further:—"Penck, Bohn, and Brückner find evidence of two interglacial epochs, and maintain that there have been three distinct and separate epochs of glaciation in the Alps."[1]

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[1] "Great Ice Age," p. 165.

[2] Ditto, p. 204.

And according to Dr. Croll's views, there must have been a greater number. For his calculations indicate that the glacial epoch lasted 160,000 years, and dividing this into periods of 10,000—the time allowed for a warm interval—we get eight such mild interglacial periods.

Prof. Geikie himself divides the ice age into periods as follows:[2]—

1) Pre-glacial mild period...	First bed.
2) First glacial period	Cromer Clay and contorted beds.
3) First interglacial mild period ...	Sand and rolled gravel above Cromer clay.
4) Second glacial period	Great chalky boulder-clay, etc.
5) Second interglacial mild period ...	Beds between great chalky boulder-clay and purple clay.
6) Third glacial period	Purple clay, lower boulder-clay of Lancashire.
7) Third and last interglacial mild period	Hessle gravel, middle sands, etc., of Lancashire.
8) Last glacial period	Hessle clay, upper boulder-clay of Lancashire.

With regard to the first point in the evidence, two suggestions occur:

(1) Beds of sand intercalated in the till *may* be in part the result of the action of the ice itself. In fact, if we do not so regard them, the composition of the till and boulder clay is a difficulty on the usual hypothesis of its origin. The products of glaciation are supposed to be these clays, and morainic debris: that is to say, very finely ground rock matter, forming the clay, with large and small stones making up the rest of the till and the morainic matter. But in the process of grinding down there must have been an intermediate product, viz. coarse and fine sand; and if these are not represented by the intercalated sand beds, where are they? And even if all the rock matter excepting the boulders and pebbles had been ground down to the fineness of the sediment forming the clay, it is difficult to understand how a purely siliceous sand could ever become plastic, and form a clay. For although the glacial clay is at times sandy, its general composition does not permit the supposition that it contains all the sand produced by the grinding down of the rocks by the ice. In fact, it seems almost certain that sand must necessarily be one of the results of ice action; and that it should occur interstratified with the till is as natural as that in a river deposit sand should be intercalated with gravel.

And in his "Ice Age in North America," Dr. Wright speaks of "the sands and gravels of the terminal moraine" of the Muir glacier (p. 47).

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[1] See Brit. Assoc. Reports, 1889, pp. 556–558.

[2] Great Ice Age, p. 393.

(2) The products of stream and ice action would necessarily be mingled *during* the continuance of the cold period. For, during summer, ice action would give place to that of water near the termination of the ice-sheet or glacier; and thus truly aqueous deposits would be formed over the glacial, to be in turn overlaid by the latter.

A succession of exceptionally warm summers, too, might cause the temporary retreat of the ice—just as in recent years a succession of exceptionally severe winters caused the formation of a veritable glacier in one of the Scotch valleys—and permit of the formation of a thicker series of sands and gravels.

And as near the extremity of a glacier or ice-sheet stream action takes the place of that of ice every summer, and to a more marked extent during a succession of warmer seasons, so we should expect to find the retreating ice, as the glacial epoch passed away, followed by a series of mixed fluviatile and glacial deposits.

And as oscillations in the extent of existing glaciers are well known, so we naturally infer it was in the past.

As regards the present day, Prof. Prestwich quotes the case of a glacier which has advanced a mile in a century, and that in a region where there is a general retreat of the ice.

And Mr. Lydekker, in his account of the Geology of Baltistan, Kashmir, describes one glacier which is retreating, and another which is advancing. Thus of the Tápsa glacier he writes:

"A comparatively modern terminal moraine, forming a dome-shaped hill covered with cypress, bounds the cultivated ground superiorly; above this old moraine is the present terminal moraine of the glacier. The above appearances seem to indicate that the Tápsa glacier has receded by small gradations, pausing here and there, until it finally attained its present shrunken dimensions."

But of the Palma glacier:

"The present Palma glacier shows pretty evident signs of being on the increase, since it terminates inferiorly in an abrupt and precipitous wall of ice, with but comparatively little debris and no distinct terminal moraine, which seems to have been overflowed and, so to speak, swallowed up by the glacier."[1]

The possibility of lacustrine action in glacial times is also suggested by the usually received interpretation of the parallel roads of Glen Roy. These are held to have been formed by a lake caused by the blocking up of the lower part of the valley by ice. While the lake stood at different levels, the action of the water formed a series of shelves on the mountain side along the margin of the lake. But it is difficult to resist the conviction, that if the lake was fed by streams, more or less lacustrine deposits would be formed in it: in other words that gravel, sand, and silt would be laid down, and afterwards overlaid by typical glacial deposits.

And stream action also, it is well known, occurs *beneath* the ice-sheet and glacier. Springs, for example, issuing from the ground beneath the ice, will cut for themselves channels through it. The great thickness of the ice itself prevents the intense external cold reaching such springs, and they may continue to flow during the cold period. We may even speculate on the probability that in those ancient days, so much nearer the period of Tertiary volcanic activity, *warm* springs were more numerous and powerful than they are to-day. At first sight the suggestion doubtless arises, that the springs would lack their usual source of supply, and early in the glacial period become dried up. But, in the first place, the surface ice is constantly melting, and the water at times sinking down through cracks to the bottom; and, in the second place, ice melts through pressure and friction such as occur beneath an ice-sheet or glacier. These two sources of supply might still feed the springs, and serve to increase the streams formed by them.

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[1] Records Geol. Surv. India, vol. xiv. pp. 44–45.

The possibility of stream action beneath a great continental ice-sheet is indicated by a study of that of Greenland. Explorers describe surface rivers cutting for themselves channels between banks of ice, and all finally disappearing by plunging down through openings in the ice to the bottom.[1] These rivers then probably flow along sub-glacial channels to the extremity of the ice-sheet, eroding the rocks, and forming fluviatile deposits as they go.

In connection with this, it may be noted, that it is held by many that more heat was received from the sun during the summer of the glacial epoch than at present, and that consequently this surface-melting, and formation of rivers would be on a larger scale.

And in "The Ice Age in North America," Dr. Wright notes the occurrence of *water-worn* débris on the ice of the existing Muir glacier: "Here a vast amount of water-worn *débris* covers the ice, extending up the glacier in the line of motion for a long distance."[2]

The streams issuing from the extremity of the ice, indeed, whether glaciers or ice-sheets, are frequently not formed merely by the melting of the ice at the extremity, but are actually rivers which have run for considerable distances beneath the ice.

Thus, writing of the glaciers of the Alps, M. Rendu describes streams running beneath the whole of that portion of the ice-river which descends below the line of perpetual snow:

"When we traverse the Glacier des Bois, at the bottom of each crevasse we admire a little stream of fresh and limpid water, which appears to flow over a surface of emerald. These streams reach the edges of the glacier, lose themselves among the stones of the *moraine*, and unite again beneath the ice at the bottom of the hollow which contains it. Other streams reach the same destination by the openings which penetrate to the bottom of the glacier; and, lastly, springs and waterfalls fall also upon the banks of the icy river, and take the same direction; so that we are sure that there is a *subterraneous river* which flows beneath the whole extent of the glacier, and which comes to light only at its lower extremity."[3]

And what we must, I think, regard as an example of the mingling of aqueous deposits with glacial occurs in the drift, near London.

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[1] Nordenskiöld, GEOL. MAG. Vol. IX. p. 393. [2] p. 62.

[3] "Glaciers of Savoy," Translation. Edited by Prof. George Forbes, pp. 156–7.

In describing the middle glacial beds, Mr. Whitaker writes: "Besides these, however, there is sometimes a layer of true Boulder Clay in the gravel, that is, a clay that contains irregularly rounded fragments or boulders of various rocks, the surfaces of which are furrowed and scratched in the way that is peculiar to stones that have been dragged along by masses of ice over a floor of rock. This clay being like that which occurs in force above the gravel, serves to link the two deposits together, and to show that the glacial conditions which seemed to have reigned supreme during the great mass of Boulder Clay existed also during the deposition of the lower bed, though to a less extent."[1]

This *layer* of Boulder clay *in* the gravel can hardly be considered as the product of a glacial epoch, followed and preceded by a mild epoch when gravel was laid down.

And there is another way in which true river sands and gravels may be intercalated in glacial beds without the intervention of a warm interglacial period. They may be *preglacial river deposits* pushed on by the advancing ice over boulder clay already laid down.

Such preglacial river sands and gravels must have been abundant, and it is usually believed that a part of the work of the ice was to sweep these down the valley. What more likely than that some of these deposits, thus pushed on, would be stranded in some quieter spot and *at times* left on the surface of already deposited till?

In writing of the glaciation of South Lancashire, Mr. A. Strahan speaks of the Boulder clay as "sometimes rudely stratified," although "usually devoid of such lamination as is shown by clays deposited freely in water."[2]

He thus further describes the alternation of sheets of Boulder clay with sand and gravel in certain districts:

"In every case where the drift attains any thickness, as in a preglacial river-valley, or the maritime plain of North Flintshire and Denbighshire, it is found to consist of alternations of sheets of Boulder-clay with sand and gravel, the beds running sometimes for a mile or two without interruption."[3]

Here, again, we cannot suppose each sheet of Boulder clay to represent a glacial epoch, and each separating gravel a mild period; we are rather bound to conclude that the glacial conditions which produce Boulder clay are able also to produce sand and gravel; that the alternations here seen are due to *merely temporary alterations of conditions*, as between summer and winter or small oscillations in the extent of the ice.

The section at Blackpool is, perhaps, one of the most favourable to the hypothesis of a mild interglacial epoch. There it is said there are two Boulder clays, separated by a series of sands and gravels.

This series of beds is described in detail with a section by Mr. T. Mellard Reade.[4]

But although it is true there is in this coast section a lower bed of Boulder clay, succeeded by a series of sands and gravels, which are in turn overlaid by Boulder clay, the general relations of the beds point rather to a partial sorting of materials produced under one set of conditions than to such a great change as that implied by a passage from a glacial to a mild climate.

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[1] Geology of London, Geol. Surv. Mem. pp. 52, 53.

[2] Q.J.G.S. vol. xlii. pp. 373–4.

[3] *Op. cit.* p. 383.

[4] Q.J.G.S. vol. xxxix. p. 83.

There is, in the first place, no sign of the denudation of the lower bed of clay before the deposition of the sands and gravels, or of the latter before the deposition of the upper clay.

Secondly, the series of sands and gravels is neither so extensive nor continuous as might be expected on the hypothesis of their interglacial origin.

At one end of the Blackpool section, for example, the only separation between the upper and lower clay is a bed of sand a few inches thick.

Further, the separation into upper and lower Boulder-clay seems merely local. In the first place, Mr. Reade points out, that in a description of the Blackpool section some years previously by Mr. Binny, *no separation* of the clay by sand and gravel is given in one particular part of the section *where there is such a separation now.* He explains this on the supposition, that, as the section is now several yards further inland, the separating beds now visible had thinned out seawards. And he suggests the probability that if the beds could be followed inland, the upper and lower clays would be found to coalesce in a similar way. The probability of this is further indicated by the sections in the neighbourhood.

Thus Mr. Reade describes one where "the Boulder-clay was divided by very persistent seams of sand, though in places these thinned out and the upper and lower beds coalesced and became one without observable division." In other cases, "the shingle is divided by patches of Boulder-clay;" while "irregular sporadic patches of sand occur in the clay."

An artificial section at Sankey Bridge is thus described:—"The Boulder-clay was here penetrated to 100 feet below the surface, the last 20 feet showed 5 feet of sand mixed with coal-dust and 15 feet of clay with bands of gravel. A sand and gravel seam 2 feet thick was passed through about 53 feet from the surface.

It is obvious, I think, that sands and gravel and boulder-clay mixed up in this way cannot be referred to distinct glacial and interglacial epochs. And if we admit a glacial origin for such patches and layers of sand and gravel, we are bound to admit the possibility, if not the probability, of a similar origin for the greater development in the Blackpool section.

The evidence of the fossils of these Lancashire Drift beds is also against the hypothesis of a mild interglacial epoch.

Thus Mr. Mellard Reade after an extensive examination of the Mollusca found in them, concludes that the intercalated sands and gravels are not separable from the boulder clays by their organic remains, *as they clearly ought to be on the hypothesis of a mild interglacial period.* "My object," he writes, "in these preliminary investigations was to ascertain if there were any organic remains by which the drift-beds might be separated into geological horizons—because, if, as some maintain, two glacial and one inter-glacial period are represented in these beds, there ought to exist, *a priori*, some decided distinction in the Molluscan fauna. I have utterly failed to detect any."[1]

That the limited mass and area of these sands and gravels, and the absence of signs of denudation between them and the Boulder-clay, is decisive evidence against their being the deposits of a mild interglacial epoch, comparable in duration to the glacial period itself, is indicated by a consideration of what would probably take place during such an interval, and by a study of post-glacial sands and gravels.

For, on the melting of the ice, river action would be intensified; vast quantities of morainic matter would be carried down by the swollen streams, and spread out over the boulder-clay of the plains in the form of sand and gravel. At the same time there would be denudation of the boulder-clay in places, and some of these denudation hollows would be filled again with gravel. In places this sand and gravel might reach the sea, and form marine deposits.

But this would not continue for very long: the streams would lose their carrying power; the gravel would no longer be carried to the lower grounds, and they would commence to *cut* their channels through the gravel, and then through the underlying boulder-clay.

This gives a clear idea of the unconformable, denuded junctions we should expect to find between the sands and gravels of an interglacial epoch, and the boulder-clays of preceding and succeeding glacial epochs. And such a course of events is indicated for the close of the glacial epoch, and the incoming of the present mild climate by a study of post-glacial sands and gravels.

In Northumberland, for example, a considerable thickness of such deposits, known as the "Upper Drift Sands and Gravels," are found overlying the boulder-clay. At the junction the latter shows signs of denudation in places, while the overlying beds show at times clear indications of being in part composed of the re-assorted boulder-clay. And since the formation of the upper beds the streams have, in many cases, cut down through sand and gravel and boulder-clay to the rock below.

Ought we not, then, to look for some evidence of a similar course of events in the relations and characters of the beds of the supposed interglacial epoch?

The glacial phenomena of the Vale of Eden, as described by Mr. Goodchild (Q. J. G. S. 1875), point rather to the intermingling and overlapping of the action of ice and water taking place more or less contemporaneously, than to distinct glacial and interglacial periods.

A few sections at the foot of Stainmoor, Mr. Goodchild points out, "show that locally a threefold division of the drift obtains." Yet he adds a little further on, "It is nearly impossible to make out any definite order of succession in the drifts in the lower parts of the valley; the few sections seen show plainly enough that masses of sand and gravel pass into, and are interwoven with clay drifts in such a way as to defy any attempt at separation over large areas, although single sections may be indicated which do show a definite sequence."

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[1] Q.J.G.S. 1874, p. 124.

An inspection of the remarkable series of sections from the cuttings of the Settle and Carlisle Railway given in Mr. Goodchild's paper, showing the intimate interweaving of stratified sands and gravels and laminated clays with till and boulder clay, indicate the utter impossibility of referring the former to a distinct period.

And it is interesting to note that, "towards the mouths of the rivers, the total quantity of clay in the whole accumulation of drift steadily decreases, until very little else than clean sand and gravel is to be found, except in the maritime districts, where the true boulder-clay comes on." For, as the ice descended the valley, the greater would be the amount of aqueous action, and the less that of ice proper.

The glacial deposits of Lincolnshire, and the neighbouring parts, may be cited as apparently favouring the view of interglacial epochs.

Mr. Searles Wood (Q.J.G.S. vol. xxiv. p. 146) divided the series as follows:—

Hessle clay.
Hessle sand and gravel.
Purple clay.
Sands and gravel.
Basement clay (Chalky boulder clay).

He maintained that there was a great break below the Hessle beds, and separated these from the glacial series altogether.

Supporters of the hypothesis of warm interglacial epochs will find evidence for these in the intercalated gravels, and in the supposed breaks in the series.

For, the result of the survey of the district by Mr. Jukes-Browne, leads him to place *another break* between the chalky boulder clay, and the purple clay, although he repudiates the break higher up established by Mr. Wood.

A consideration of the facts brought forward by Mr. Jukes-Browne (Q.J.G.S. vol. xli. p. 114), in his paper on the Boulder clay of Lincolnshire, shows that the series of deposits—even if the above division can be shown to be chronological—does not necessarily indicate climatic changes.

In the first place the chalky clay and the purple clay are not found together in one district; the former occurs on the west of the Wolds, and the latter on the east.

"In East Lincolnshire," says Mr. Jukes-Browne, "there are only three localities where the Brown Boulder-clay comes into contact with the White Boulder-clay." And after describing these junctions, he concludes that the appearances at these places are not against the supposition that the brown clays *pass into* chalky clay.

Other considerations, however—which do not appear to me conclusive—incline him to conclude that the two clays are separable chronologically. But, whether this is so or not, the fact remains that, in the absence of sections, there is here no evidence of an interglacial epoch between the periods of the chalky and purple clays.

Again, glancing at Mr. Jukes-Browne's map, one is inclined to ask, why, on the hypothesis that the formation of the purple clay *was subsequent* to that of the Chalky, none of the former was laid down *on* the latter over all that region west of the chalk Wolds where it occurs; while at the same time it *does* occur further west and north away from the chalky boulder clay? And why, on the other hand, the chalky clay is not found beneath the purple on the east of the Wolds?

As regards the division between the purple and Hessle clays, Mr. Jukes-Browne shows that the sands and gravels separating them graduate into both lower and upper clays; the sand beds containing patches of boulder-clay, and the latter beds of sand in the usual way. He concludes finally that there is no break between the clays.

The presence of *Cyrena fluminalis*, noted by Mr. Wood in the Hessle beds, may be taken as an indication that the climate was ameliorating as the ice gradually disappeared.

Prof. Geikie points to the Interglacial beds of other countries as additional evidence of mild interglacial periods in our Northern hemisphere—he claims it, in fact, from every country yet examined:

"In every country where the glacial deposits have been studied, we have clear proof of a mild interglacial period having supervened."[1]

The intercalated beds of Switzerland are of special interest, consisting as they do of seams of lignite from two to five and sometimes even twelve feet thick, and which have been worked for fuel. They are made up of the remains of peat-forming plants, and rest on sand and clay, beneath which is the grund-morâne. Remains of Pines, Oaks, Birches, Larches, etc., occur in these lignites, from which Prof. Heer, has inferred that the climate, at the time of its formation, was the same as that of Switzerland at the present day.

The inference drawn by Prof. Geikie is, "that the great *mer de glace* eventually vanished from the low grounds, and the glaciers shrunk back again into the deep mountain-valleys. The climate grew as mild as it is at present. Oaks, Pines, and other trees overspread the ground, and many large animals became denizens of Switzerland. That this condition of things must have endured for a long time no one can doubt. Nor could the change from the intense glacial climate of the great *mer de glace* have been other than gradual. The glaciers would slowly retire, and many ages would elapse before the condition became such as to induce the growth of Oak-trees. After the genial climate that nourished these trees had lasted for untold centuries, the cold again increased. Slowly the glaciers crept down the valleys. Little by little, year by year, they continued to advance, until at last, escaping from the mountain-valleys, they deployed upon the low grounds. And now, encroaching upon, and eventually occupying the basins of the

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[1] Great Ice Age, p. 491.

Alpine lakes, they crept out from these and piled up great end-moraines upon the lower grounds beyond."[1]

Prof. Heer's inference as to climate is, however, somewhat inconclusive. Pine, Oak, Birch, and Larch are doubtless native trees in Switzerland at the present day, but do they not occur up to such heights that they might easily be mingled with the deposits of the present glaciers, especially during some of those minor oscillations to which these are subject? And if those in the lignites are proved to be intercalated with glacial deposits, it may not mean any more than that these temperate forms of vegetation approached the ice of the glacial period as nearly as the same trees approach the ice of to-day. But the evidence that the growth of these trees was succeeded by a glacial period is less satisfactory than that it was preceded by the same.

The lignite is surmounted by sand and gravel upon which are several large alpine erratics. This is certainly suggestive, but hardly sufficient; for, to quote the authors of the Manual of the Geology of India, such "presumed erratics" are the "least certain form" of evidence of glacial action. And in considering such the enormous carrying power of Alpine torrents is perhaps too much lost sight of.

"But," says Prof. Geikie, "the erratic blocks that overlie the lignite are not the only evidence of this second advance of the glaciers. That the ice after retiring from the Jura to the mountain-valleys did again invade the low country had been inferred before the interglacial character of the lignite beds was discovered. It had been known for years that the first ground-moraine and ancient alluvium were overlaid by newer ground-moraines, terminal moraines, and alluvium; the meaning of this having been pointed out by Morlot as far back as 1854."[2]

The facts adduced by M. Morlot, however, can scarcely be considered conclusive evidence of two glacial epochs separated by a prolonged warm interval.

In his paper he speaks of two glacial periods, a *general mighty glaciation*, and a *more limited local glaciation*. The evidence adduced is the presence of "diluvial drift" on boulder-clay.

"*During* the diluvial period," he writes, "the glaciers had entirely disappeared, as has been shown, whilst *after* the diluvial period the glaciers returned, leaving on the diluvial terraces abundant deposits."[3]

M. Morlot mentions examples of this "diluvial drift" *overlaid by erratics*, and *others* of the same drift *lying upon* till; but he brings forward *no case* where it lies *between* glacial beds.

The formation of the loess is attributed to the glacial period. The evidence of the glacial origin of the loess, however, is far from certain, nor is the opinion that it thus originated by any means universal among geologists; so that any argument drawn from its presence on supposed interglacial beds is inconclusive.

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[1] Great Ice Age, pp. 405–6.
[2] Edinburgh New Philosophical Journal, 1855, p. 14.
[3] Edin. New Phil. Journ. 1855, p. 18.

Prof. Geikie agrees with M. Morlot as to the relative severity of the two glacial epochs:

"The glaciers of the second period, although of very much larger dimensions than their puny descendants of to-day, yet were themselves but pigmies as compared to the gigantic ice-flows of the first period."

But surely it would be difficult, or even impossible, to distinguish between glacial deposits formed at two distinct epochs of such character separated by a mild interval, but with no distinct memorials of the latter, and a series of deposits formed by ice-sheets and glaciers continuously or intermittently retiring. If the ice, after gradually retiring to a certain point, made a prolonged pause before finally shrinking to its present limits, we might expect to find two *apparently* distinct sets of deposits such as those described, and one of which indicated a much more limited extent of ice. In fact, all the phenomena of these Swiss beds here mentioned are not only possible on the hypothesis of an oscillating and intermittently retiring body of ice, but are exactly such as we should expect on this view.

And Prof. Prestwich does not consider the evidence of these beds —nor indeed the evidence for interglacial periods generally—as conclusive.

"It is asserted," he writes, "that in Europe there were interglacial periods during which the ice disappeared from the surface for great lengths of time. But either the evidence is insufficient or it points to slight temporary effects, except in one case, which is of more importance, and on which the greatest stress is laid, namely, that of Dürnten in Switzerland. There beds of lignite with mammalian remains are intercalated between two glacial deposits. Admitting the fact that the lignite rests on beds of undoubted glacial (ground-moraine) origin, and that the trees grew on the spot where their stumps and remains are found, it by no means follows, as contended, that because these trees are all of species now living in Switzerland, the temperature was that of Switzerland of the present day. *Pinus sylvestris*, *Abies excelsa*, the Yew, the Birch, and the Oak flourish equally in Sweden and far north in Siberia. On the other hand, there is one species of *Pinus* (*P. montana*) which is spread over the mountain country up to heights of 7000 feet, and is rare in the low lands; while one of the Mosses is closely allied to a species now growing on the hills of Lapland. The few species of Mammalia have a distinctly northern facies. *Elephas primigenius*, *E. antiquus*, *Ursus spelæus*, as also *Cervus elaphus*, and *Bos primigenius*, are commonly associated with the Reindeer, Musk, etc., and other Arctic animals of the cold post-glacial times.

Is the return, therefore, of the retreating glacier, supposing the boulder-gravel above the lignites of Dürnten to be due to direct ice-action, to be ascribed to anything more than a comparatively slight temporary change of climate, like those that now for a succession of seasons cause, from time to time, a temporary advance of the glaciers, only more marked? We must allow, of course, for greater differences and longer intervals of time than now obtain. . . . . But the beds of stratified sand, gravel, and boulders overlying the lignite are more likely to have been the result of glacial torrents than of the direct super-position of the ice which may have again approached, but is not proved to have ever covered the spot."[1]

(*To be concluded in our September Number.*)

II.—Notes on the "Pleistocene Beds" of Gozo.

By J. H. Cooke, F.G.S.

In the year 1874 a letter signed by Messrs. Feilden and Maxwell appeared in the Maltese Journal "Il Barth," in which attention was drawn to a Post-pliocene deposit, said to have been found in the vicinity of Cala Dueira and Il Kala, in Gozo.

A specimen of the deposit, together with a number of shells, that were found in the bed, were forwarded to Prof. Seguenza, who, after having examined them, expressed an opinion that the discovery was one of much importance. From that time to this no further attention appears to have been paid to the matter.

During the latter portion of the summer of 1890 I was engaged in investigating the geology of the Dueira district, and, it was in the course of one of my expeditions that I first discovered evidences of the bed to which Messrs. Maxwell and Feilden had alluded seventeen years ago.

Cala Dueira is a small bay, which is situated at the western extremity of Gozo. Its southern and eastern shores are bounded by mural cliffs of Lower Coralline Limestone,[2] that tower above the level of the sea to a height varying from 150 to 200 feet.

In consequence of a fault, that extends from Monsciar at the head of Wied-el-Arab to Dueira, the eastern boundary of the bay has been let down, and the cliffs are, therefore, no more than 20 feet high in some parts, while towards the west the strata shelve gradually off, and finally disappear in the sea.

At the mouth of the bay there is an outlier of the Lower Coralline Limestone, which is known as the "Fungus" or "General's" rock. It once was apparently a continuation of the now depressed northern boundary. The bay, itself, forms the embouchure of the Dueira valley, the catchment area of which is bounded on either side by a fault of considerable magnitude. That on the northern side extends from the "General's" rock to the northern base of the hill known as Ghar-Ilma. The down-throw that has resulted from this

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[1] Q.J.G.S. 1888, pp. 402–3.

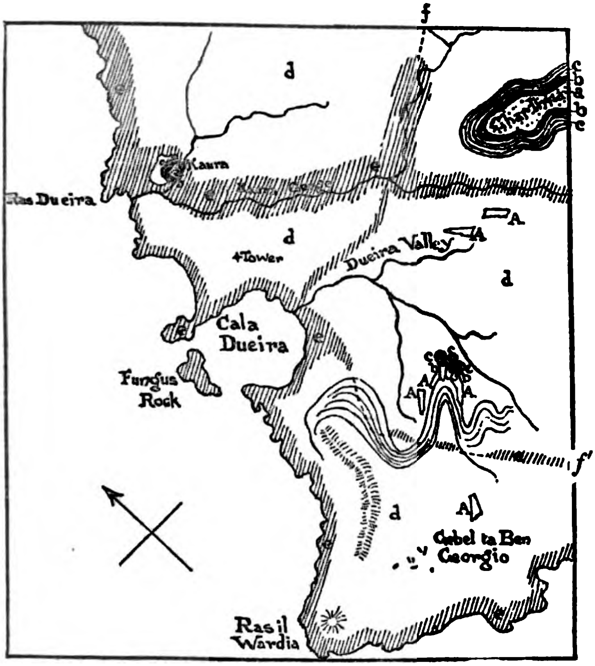
[2] The following table shows the order in which the Maltese formations occur:—

Dr. Murray's Classification.	Capt. Spratt and Dr. Adam's Classification.
I. Upper Coralline Limestone.	I. Upper Coralline Limestone.
II. Green Sands.	II. Sand bed.
III. Clay beds.	III. Marl beds.
IV. Globigerina Limestone.	IV. Freestone.
V. Lower Coralline Limestone.	V. Lower Limestone.

fracture, has depressed the area to the south of it to about 40 feet below the top surface of the Lower Limestone escarpment, that lies exposed along the line of fault.

The fault on the southern side of the bay extends from Dueira *via* Monsciar to Miggiar Scini, and the result of its fracture has been to depress the area to the north of its line.

The accompanying map will show the relative positions of these two faults, and the effect that they have had on the area that lies between them.



Map of a Part of the Island of Gozo, near Malta.

Explanation.

a. Upper Coralline Limestone; *b.* Green Sands; *c.* Marl;
d. Globigerina Limestone; *e.* Lower Limestone;
f. line of fault which has disappeared North of Ghar-Ilma;
f'. line of fault extending to Monsaar, and thence to Miggiar Scini;
A. Pleistocene.

The strata that have thus been let down are much broken and displaced; and, on the southern slope especially, there are several minor faults, all of which wend in a direction that is at right angles to the main fracture.

The beds on both sides of the valley slope at varying angles, in many cases the inclination being as much as 45° and even 60° out of the horizontal. The beds dip inwards, and the result of the synclinal depression, which has thus been formed, is the Dueira valley, the bed of which is represented by the trough of the syncline.

The southern slopes are very uniform in outline; but those on the northern side are divided into a series of smaller valleys or gullies, down which miniature torrents pour their waters for a few occasional hours in the winter time.

The deposits of which the valley is composed do not consist of the Lower Coralline Limestone as is represented in the Geological Map of the Island, which was published by Ducie, Spratt, Adams, and Murray. On the contrary, the Lower Limestone is entirely absent save where it is exposed along the lines of faults that bound the valley; and the deposits consist of all of the beds that are found interstratified between the uppermost and the lowermost of the series. The Globigerina Limestone is the predominant rock; but the blue and yellow clays,[1] and the Greensands,[2] are also to be found *in situ* along the southern slopes.

Fringing the upper portion of the sides of the valley the Lower Limestone may be seen marking the line of fault, with the Globigerina beds of the undisturbed district above it, and those of the depressed area beneath it. The former relation that existed between the depressed area and its surroundings is therefore distinctly apparent.

I have entered thus into detail because some misapprehension appears to have formerly existed with reference to the geology of this part of the island. Instead of being a valley of erosion similar to the Kaura, the Scini Sclendi, Asel and the Yebbug gorges, it is simply a depressed area, which has been let down by the dislocation of the strata on either side of it. It is also important that these details should be carefully considered; as on their correct representation depends the evidence that must be adduced for proving the the relationship which formerly existed between the Pleistocene deposits found in the valley below the line of fault, and those found on the summit of the slopes above it.

It was while engaged in noting the points of difference between the geology of the district, as it is represented on Ducie's map, and that which actually exists, that I first came across the Pleistocene bed which I am about to describe.

Starting at the head of the valley and proceeding towards its mouth, the Globigerina strata will be observed sloping down the valley side at angles of varying magnitude; and breaking off abruptly towards the lower part, thus forming cliffs of from 10 feet to 15 feet in height. Fringing the slopes that lie beneath these escarpments, there is a bed of white limestone, overlying a bed of yellowish grey loam.

The deposit may be traced for some distance down the valley; but in some places owing to the denuding action of several small streams, that have cut their way, it will be found to occur in patches only.

It is elevated at a height of from 20 to 30 feet above the present bed of the valley; and it extends, East and West for a distance of about thirty yards, and North and South for about fifteen yards.

[1] Bed III.

[2] Bed II.

It is lenticular in shape, but breaks off abruptly at the lower side, and an escarpment is thus formed, which shows the maximum thickness of the bed to be about 7 feet, while at the extremities it thins out to 18 inches and a foot.

Its upper surface is extremely hard; and like the surfaces of the surrounding strata, it has been considerably honeycombed and otherwise weather-worn.

The materials of which it is composed are very uniform, both in general appearance and in arrangement. They consist for the most part of fine detrital matter, the product, apparently of the erosive action of the atmosphere on the Upper Coralline, the Greensands and the Globigerina beds.

The deposit is divisible into two well-marked zones, the most persistent features of each of which are the irregularity of its divisional planes and its non-crystalline character.

The top zone consists of an impure, perfectly formed limestone of a whitish colour, and it is usually overlain by a thin, stalagmitic layer of about one inch or less in thickness.

A chemical analysis showed a sample of this bed to consist of about 80 per cent. of carbonate of lime.

In many parts of the bed, minute perforations are noticeable traversing the rock in all directions. They vary considerably both in length and in the diameter of the bore. None of them exceed $\frac{1}{16}$th of an inch in diameter, while many of them are much less.

These capillary tubes often play an important part in determining the direction in which the rock cleaves. They are, however, not persistent throughout the formation, and are more numerous in some parts than in others.

This upper division of the deposit is very fossiliferous; but, owing to the imperfect character of the rock, the Mammalian remains are seldom found in a perfect condition, and even when found entire, they are often so rotten that they fall to pieces under the slightest pressure.

Besides large quantities of land-shells, and mammalian remains, the teeth and vertebratæ of Sharks, Echinoderms, several species of Corals, and other representatives of a marine fauna occur. All of these latter have, however, been derived from the Globigerina Limestone.

The following is a list of the organic remains that I have found in this bed.

MARINE.

Two teeth. (*Oxyrhina hastilis*).
One tooth. *Oxyrhina xiphodon.*

(Both of these species are characteristic of beds 2, 3, and 4.)

Flabellum, Zoantharia, and Corallines. One Echinoderm (*Schizaster*, sp.).

LAND SHELLS.*

Helix vermiculata (Müll.) (common).
Helix pisana (Müll.) (common).
Helix striata (Drap.).
Helix virgata ? Mont.
Helix caperata ? Mont.
Pomatias melitensis (Sow.).

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* Kindly identified by Mr. E. A. Smith.

FORAMINIFERA.

In the washings of about two pounds of the material, the following species were observed:

Orbulina universa, d'Orb.
Globigerina bulloides.
Cristellaria sp.?
Clavulina cylindrica, Hantken.
Truncatulina ungeriana, d'Orb.
Nodosaria sp.? (broken).
Nodosaria obliquestriata, Reuss. (broken).
Many fragments of others.

Of the land shells the most numerous are those belonging to the Helicidæ.

The specimens are always found in an excellent state of preservation, and in some cases even the original colour of the bands being preserved. Minute specimens of *Helix virgata*? appear present in the greatest abundance; and by washing a portion of the deposit in a sieve, considerable quantities of them may be obtained.

Next in descending order occurs a layer of yellowish grey loamy earth, but the transition between it and the overlying limestone is so gradual, as to render it a matter of considerable difficulty to determine where the one ends and the other begins.

Being of a loose texture the bed easily disintegrates, and thus, by undermining the superincumbent strata, it causes portions of them to break away from the main mass and roll down the slopes.

This loam, like the overlying limestone, abounds in fossil land-shells; but no Mammalian remains appear to be present. Water-worn pebbles of all shapes and sizes are to be found interspersed throughout every part of the bed; but in the loam, though they are more numerous than in the indurated rock above; they are, in the aggregate, much smaller. An examination of a number of these pebbles shows that they have been derived from the three great limestone formations of the islands (Beds I. IV. and V.) in, approximately, the following proportions:—

Bed I.	Upper Limestone	10 to 15 per cent.
Bed IV.	Globigerina Limestone	50 to 70 ,,
Bed V.	Lower Limestone	20 to 30 ,,
	Black Limestone	10 to 15 ,,

All of these pebbles are much harder than the rock from which they were derived; and, when broken, they usually present the appearance of a hard external ring of rock of a semi-crystalline character, within which is encased a nucleus of limestone, that is similar in every respect to the rock of the bed from whence the pebble bed had been derived.

This change in the external part of the pebble is apparently due to the infiltration of the limewater, which, after depositing its burden of lime in the interstices of the stone, slowly evaporated, and thus leaves the stone more compact and of a closer texture that when the water was first absorbed in it. The same phenomenon is observable wherever the Limestone beds of the Maltese Series crop out as a surface deposit.

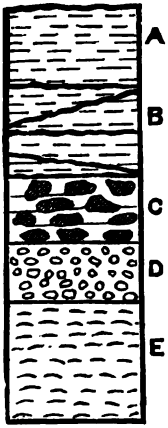
Another remarkable feature of this Pleistocene bed is the extraordinary quantity of Black Limestone pebbles that occur in it.

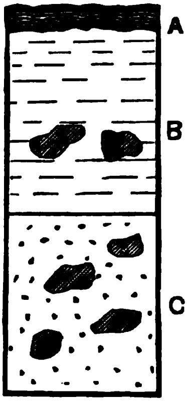
Notwithstanding a diligent search in the district around, I was unable to discover any traces of a formation partaking of the lithological characteristics of these pebbles, to which they might have been referred.

Proceeding down the valley in a westerly direction, four mounds of blue and yellow clay (the marl beds of Spratt and Adams), are to be seen resting conformably on the southern slope, at an elevation of about 20 feet above the bottom of the valley; and in two cases, the black and yellow sands, that are invariably found to overlie the stratum, are also present.

On the summits of these clay-beds, there occur other patches of the Pleistocene deposit; but unlike those portions that have just been described, these are not *in sitû*, but have been formed, apparently, by the degradation of beds, that were originally deposited higher up the slopes. The materials of which these cappings are composed appear to differ but little from these of the other portions of the bed, save in the total absence of perfect shells, and the comminuted condition in which the fossil bones are found. Such are the principal characteristics of the Pleistocene deposits that are found along the southern slope of the Dueira valley.

The following sketch shows the relative positions of the subdivisions.





A. Greyish, non-crystalline, slightly indurated limestone. Helices and other land-shells occur in abundance; but no Mammalian remains appear to be present.

B. Limestone of a similar character to A, but interstratified with irregular layers of stalagmite. These layers vary from ¼ to ⅛ of an inch in thickness.

C. A layer of boulders and pebbles, all of which have apparently been derived from beds IV. and V. Some of the boulders measure eighteen inches, and two feet in length; and all of them are rounded, and otherwise much water-worn.

D. Loam intermixed with quantities of smaller pebbles. Black limestone pebbles occur in this layer in abundance.

E. A yellowish grey loam, similar in every respect to that which occurs at the base of the other deposits. It abounds with Helices and other land-shells, but no Mammalian remains were found in it.

If, now, the road which winds up the hill-side towards Gebel-ta-Ben-Giorgio, be traversed, the observer will pass from the Globigerina Limestone of the depressed district, across the line of fault marked by the Lower Limestone, to the Globigerina above it.

On the right-hand side of the pathway, that runs through this elevated region, and at a distance of about a quarter of a mile from St. Georgio, another remnant of the deposit may be seen.

Passing down the hill again, and crossing to the northern slopes of the valley, another development of similar accumulations, of even greater extent, will be met with.

These beds, however, present many striking points of dissimilarity to those on the opposite side of the valley. Like the deposits on the southern slope, they extend in an east and west direction, and lie unconformably on the Globigerina Limestone. They occupy a kind of platform on the hill-side, and towards the lower boundary they break off and form an escarpment of from 6 to 8 feet in height. Approaching the valley from the Kaura Gorge, an excellent section of the bed is to be met with about 150 yards down the slope. Its face forms the northern boundary of a field, a large portion of the soil of which has, apparently, been derived from the deposit. This section shows the bed to be made up of a number of layers, each of which differs in a most marked manner from those above and below it.

It will be seen, therefore, that, though agreeing in some respects with the formation on the opposite side of the valley, there are also many important points of dissimilarity.

The most striking of these may be seen in the following table of comparison.

Deposit on the Southern Side.	Deposit on the Northern Side.
a. Boulders are comparatively small, and are interspersed throughout the bed.	a. Boulders are large, and are distributed in well-defined layers.
b. The loam is overlain by a single layer of limestone.	b. The loam is overlain by alternating layers of pebbles, boulders, limestone and stalagmite.
c. Mammalian remains.	c. No Mammalian remains.

The distinct evidences of stratification that are apparent in every part of the beds offer unequivocal proofs of their aqueous origin; and that is a conclusion that is still further borne out by the rounded and otherwise water-worn state of the pebbles that occur so plentifully in them. The finer materials, the pebbles, the shells, and the Mammalian remains have all apparently been collected from the surface of the surrounding country by the agencies of freshets, and inundations of a similar character.

From the evidences afforded by the nature and position of the various portions of the deposits, it would seem as though the surface configuration of the district has undergone changes of a marked description since these beds were formed. Thus the occurrence of patches of the bed both above and below the line of fault would seem to indicate that their deposition must have taken place antecedent to the downthrow to which the now-existing valley owes its origin.

What the immediate causes were that gave rise to the flood-waters, it is not my purpose here to attempt to determine. That no ordinary floods such as now occasionally occur in the winter months, effected the work of erosion in the Kaura and Dueira districts is a fact that no one would feel inclined to dispute, after seeing the precipitous and rugged sides of the Kaura Gorge, a valley of erosion that lies a few hundred yards to the north of the Dueira valley. The denuded condition of the surface in these localities points to the action of torrential volumes of water; and it was, probably, to the occasional overflow of these from their ordinary channels, combined with the transporting action of the rain on the slopes, that the deposits that form the subject of this article owe their origin.

III.—ON *ORTHOCERATITES VAGINATUS*, SCHLOTHEIM.

By Arthur H. Foord, F.G.S.
Royal Dublin Society.

I HAVE lately been favoured by Dr. W. Dames with a separate copy of a communication made by him to the Neues Jahrbuch für Mineralogie, etc.,[1] dated Berlin, 18th December, 1890, in which he points out that in my Catalogue of Fossil Cephalopoda, British Museum (Nat. Hist.) part i. (1888) I have (following Eichwald[2]) wrongly referred a certain "smooth" species of *Endoceras* from Reval in Esthonia, to the *Orthoceratites vaginatus* of v. Schlotheim, —a ribbed species. Dr. Dames states, in the above communication, that he was asked by Dr. Lindström of Stockholm (at the time when the latter was occupied with his edition of the "Fragmenta Silurica") if he could inform him to what species v. Schlotheim had given the name *Orthoceratites vaginatus*. Dr. Dames' reply to this question was inserted by Dr. Lindström in the midst of a very full table of synonymy of *Orthoceras* [*Endoceras*] *vaginatum*,[3] and in that rather obscure situation it escaped my notice. The reply in question was to the effect that the examples of v. Schlotheim's type, sent by Dr. Dames from the Berlin University Museum to Dr. Lindström, were without doubt v. Schlotheim's species.[4] The latter (widely distributed in Esthonia, Sweden, and Oeland[5]) has more or less distinct transverse costæ, and is also covered with conspicuous transverse striæ. On the other hand, the species described by Eichwald under the name *Orthoceras vaginatum* (and by the present writer under that of *Endoceras vaginatum*) has a "smooth" test, numerous chambers, and a remarkably large siphuncle, larger in fact than that of v. Schlotheim's species. Doubtless, continues Dr. Dames, Eichwald was led into this error by v. Schlotheim's citation of a figure in Breyn (Dissertatio physica de Polythalamiis, etc., 1732, p. 36, t. v. ff. 1–4), which apparently represents a smooth *Orthoceras*. Dr. Dames then goes on to say that the specimens called *Orthoceratites vaginatus* by v. Schlotheim himself in the palæontological collection of the Royal Museum of Natural History in Berlin are all typical, well-preserved specimens of *Orthoceras vaginatum*, with ring-like swellings [costæ], and distinct striæ. When, observes Dr. Dames, v. Schlotheim published his "Petrefactenkunde" [1820], he possessed only Esthonian specimens; but later on he received several from Oeland, and as they were identical with the others, he placed them in the same species, and labelled them accordingly. In the Catalogue of Schlotheim's collection, printed in 1832 (p. 32), Oeland is mentioned as the locality, and the quotation from the "Petrefactenkunde" has been added. It therefore appears, says Dr. Dames, that in his reference to Breyn v. Schlotheim has compared a species with *Orthoceras vaginatum* that has no connexion with it. Concluding his remarks, Dr. Dames says that all the specimens in v. Schlotheim's Collection, which he [v. Schlotheim] has named *Orthoceras vaginatum*, belong to the species (recognized as such by all authors except Eichwald and Foord) which is distinguished by its transverse ribs and striæ.

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[1] 1891, Band i. Zweites Heft. Breifl. Mittheil. ii. p. 210.

[2] Leth. Rossica, 1860, vol. i. p. 1243.

[3] Fragmenta Silurica, Angelin and Lindström. 1880, p. 2.

[4] The following is a translation of v. Schlotheim's description of "Orthoceratites vaginatus" (Petrefactenkunde, 1820, p. 53):—"Very beautiful and instructive examples from Reval, in Ueberg. Kalkst., some part still in the matrix, some free, and only about five inches long to a diameter of one inch; besides separate pieces of its remarkable siphuncle. Cf. Knorr, pt. iii. suppl. t. iv*b*. and Breynii opuscula, t. v. f. 2*b*., where this Orthoceratite, together with its elegant, somewhat cylindrical siphuncle is tolerably well portrayed. The length and thickness attained is, it appears, very considerable, whilst the siphuncle belonging to it is found of considerable stoutness. Its relation to the other part of the Orthoceratite is so important that it almost appears as a part of the shell-wall of the latter. It runs, moreover, close to one side of the shell, which in most of the representations of it is not properly indicated, and its protuberances have somewhat of a screw shape; very ornamental, as if elaborately designed. The shell itself is very distinctly oblique, with sharp, somewhat forwardly projecting lines, striated in the direction of the chambers, which latter are bent inwards somewhat stronger towards the siphuncle."

[5] An island in the Baltic, off the east coast of Sweden.

In strict equity v. Schlotheim's name *vaginatus* ought long ago to have been superseded in favour of Hisinger's *trochleare*, because the former was admittedly inadequately described, while the latter was not only described, but figured,[1] in an intelligible manner. It is true that Hisinger had an inkling of the form to which v. Schlotheim had applied the name *Orthoceras vaginatum*, for he inserts that name (though with a note of interrogation after it) under his description of *Orthoceras trochleare*. That v. Schlotheim's description of *Orthoceras vaginatum* was unintelligible even to those who had abundant specimens of it at their command, is clearly proved by the fact that Dr. Lindström was obliged to appeal to the type-specimens in Berlin to ascertain what was the species to which v. Schlotheim had applied that name.

However, in deference to Dr. Lindström's authority, added to the testimony afforded by the specimens at Berlin under the care of Dr. Dames, I cannot but assent to the adoption of Schlotheim's name for the species in question, and I take this opportunity also of tendering my thanks to Dr. Dames for pointing out the error into which I fell with reference to Eichwald's species. On comparing a specimen of the latter in the British Museum with the *Endoceras zaddachi* of Schröder,[1] I can see no reason for changing the opinion I formed about it when writing part i. of the Catalogue of Fossil Cephalopoda, viz. that the two species are identical. The *vaginatus* of Eichwald (non Schlotheim) becomes therefore a synonym of *zaddachi*, Schröder, and not vice versa, as in my Catalogue.

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[1] Lethæa Suecica, 1837, p. 28, Tab. ix. fig. 7. The name *Orthoceras* [*Endoceras*] *trochleare* appears to have been originally bestowed by Dalman. See Hisinger's Anteckningar i Physik och Geognosie, femte häftet, 1831, p. 12, Tab. iv. fig. 3.

IV.—PHYSICAL STUDIES OF AN ANCIENT ESTUARY.[2]

By the Rev. A. IRVING, D.Sc., F.G.S.

IT is needless to recapitulate, for the information of the readers of the GEOLOGICAL MAGAZINE, all the incidents which are known to accompany the formation of new land by rivers, or to repeat the descriptions which have been given of the more remarkable instances of them, such as those of the Nile, the Mississippi, the Ganges, the Rhone, the Po, and the Danube. These have been scientifically discussed long ago, by Lyell in his *Principles*. The object of this paper is rather to suggest how a careful collation of such facts as may be learned in connexion with the formation of modern deposits at the mouths of great rivers, or in great estuarine areas (such as the Wash), which receive a number of streams from widely-extended inland catchment-basins, may throw light upon the history of older formations of the same kind, and more especially of those of Tertiary times, during which many important changes were wrought in the physiography of the continent of Europe.

As instances of the work done by rivers in making new land, especially when aided by tidal action, within historic times, one might cite the case of the Po, co-operating with the Alpine rivers which come down from the Venetian Alps, forming a great series of lagoons around the head of the Adriatic Sea, or the advance of the land upon the sea, which has placed the town of Ravenna (a sea-port under Augustus) several miles from the shore; or again, the proved advance of the delta of the Rhone upon the Mediterranean, which has been found to place the Tower of St. Louis a league or so further from the shore in the short space of a single century. But these, and such cases as these, are hardly necessary, when we have here in our own Humber the formation of *Sunk Island* within the course of a few centuries. This island (so-called) is probably well known to Yorkshiremen, but perhaps a comparatively small number of them are aware of its importance, from a geological point of view, as a testimony to the work done by rivers in compensating to some extent the work of degradation and denudation of the higher parts of the country, which is ever in progress, year in year out. This island has been formed by the deposition of sedimentary materials by the rivers Ouse, Trent, and Hull, as their onward flow has been checked, and their transporting power proportionately lessened, by the counter-force of the tides, rushing up the estuary of the Humber; a process, to the reality of which every 'dredge' employed bears testimony. This process, which the French geologists aptly term 'atterrissement,' is well exemplified in the fact that Sunk Island (a genuine island under Charles II., then just raising its head above the water-line) presented 140 years ago an area of 1500 acres, and was, even then, being brought under cultivation. About the beginning of the present century its acreage was doubled to 3000 actually under cultivation; and in 1854 the survey returns gave between 6 and 7 thousand acres, showing that in the present century the rate of alluvial deposit taking place has greatly increased. The saying of the first Napoleon that Holland naturally belonged to France, because it was made up of the mud of a French river (as he considered the Rhine), is, I dare say, well known.

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[1] Schrift. der physikal-ökonom. Gesell. zu Königsberg, Jahrg. xxii. Abth. i. p. 93, Taf. iv. ff. 5, *a–d*.

[2] Paper read before the British Association, Section C, at the Leeds Meeting, 1890.

Prof. Green in his valuable and deservedly popular text-book of "Physical Geology" has discussed the geological principles involved in the formation of a great series of estuarine deposits, with their constant alternation of fresh-water, brackish, chemical and terrestrial formations, their current-bedding, and the wedge-shaped interlacing or interdigitation of beds of different mineral composition. This interdigitation arises for the most part when a series of rivers draining tracts of country of different lithological character, converge to a common estuary; but in cases where the deposits have been laid down, and the process of atterrissement has gone on, in the neighbourhood of the mouth of one great river (with perhaps minor affluents) this characteristic is less marked, and we then find that the *vertical* variation of the rock-character of the series constitutes its principal feature, the successive deposits being traceable over miles of country.

My own studies of the Bagshot Beds of the London Basin have led me to regard them as in the main a mixed series of fluviatile, terrestrial and truly estuarine deposits, laid down under some such conditions in later Eocene time. There is a general vertical sequence traceable through the area, as Prestwich recognized long ago, with variations laterally of percentage of lithological constituents and homogeneity of structure, of the several beds. By the term 'estuarine' I mean to indicate those deposits which are laid down in the open area into which the river flows, and to which the ocean-tides have access; a connotation supported both by etymology and the usage of earlier writers on geology. Such deposits are thus distinguished in a real sense from those which are deltaic or fluviatile. A parallel case might be cited in the still older Eocene series known as the Lignitiferous Series of the Soisonnais; a series of numerous alternations of sands, clays, and beds of lignite, while the fossils met with indicate a special régime; shells of mollusca essentially *marine* (as *Ostrea* and *Pectunculus*) occurring along with others (such as *Melania, Melanopsis, Neritina, Cerithium*) which are known to prefer the mouths of great rivers for their habitat, while such strictly freshwater shells as *Paludina* are also found.[1] Now the Bagshot Series do not present us with quite such a complex of alternating conditions as is recorded in the Lignitiferous Series of the Soisonnais: they rather mark a progressive series of changes from strictly fluviatile conditions to those which prevail in a marine estuary. The *physical*, the *stratigraphical*, and the *palæontological* lines of evidence all agree in testifying to this fact; a fact that can only be satisfactorily explained by the phenomenon of a slow subsidence with intermittent pauses of long duration, during which the relative levels of sea and land remained pretty stationary.[2]

The starting point in the investigation of the physical history of the London Bagshots was the discovery of the *organic origin of the green colouring matter* which is so commonly found in these sands at certain horizons. Various salts of iron are formed in this way, which ultimately break up by exposure to atmospheric oxygen; their non-metallic constituents are resolved into carbonic acid and water, while the iron is precipitated as limonitic mud. So completely was this proved to be a true process of nature, that I was able to make it the basis of a process for the purification of water contaminated by dissolved vegetable matter, for which a patent was granted me in the year 1885. Not only limonite but iron pyrites is formed, the latter by the sulphur, furnished by the decay of vegetable albuminous matter, attacking iron. Both these minerals are of very common occurrence in the Lower and Middle Bagshot strata; and both serve as cementing material for *nodules* which we frequently meet with both in the sands and in the more sandy varieties of clay. Even *lignite* in a fragmentary state is not uncommon, reminding us of the great brown-coal deposits of the Continent of about the same age.

The *limonite* is deposited in large and small concretionary masses, and sometimes in continuous layers, resembling in every way that which is dredged up from the Swedish and Canadian lakes, to be utilized as iron-ore; the excellent quality of Swedish iron being largely due to the fact that a pure chemical precipitate of iron oxide is thus made the basis of its manufacture. As there the conditions of primeval forest prevail over a large proportion of that Archæan region, and the decay of forest litter furnishes the acid solvents for the leaching-out of iron from the rocks, the iron being precipitated as the water undergoes oxygenation in the shallow lakes; so here in this ancient Eocene delta vegetation has by its decay furnished the solvents; the same cycle of change, and the same laws of nature have been in operation. As solvents, too, of *silica* in the presence of strong bases, these organic acids may have played their part in the formation of the *glauconite* (essentially a mixture of hydrous silicates of potash and the oxides of iron[1]), which gives such a marked character to the green earthy sands of the Middle Group, and helps to testify to their lagoon-origin. [The minute flakes of glassy silica described in previous papers, as well as the secondary crystals on the quartz grains, are, I believe, authigenous products; while the *abraded* scales of mica, so common in the sands associated with the clays of the formation, are in all probability allothigenous material, testifying to the erosion and denudation in later Eocene time of the crystalline rocks of the mountain-system to the west, which furnished the head-waters of the great Eocene river.]

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[1] See Prof. Stanislas Meunier, "Les Causes Actuelles en Géologie," pp. 269, 270.

[2] I may be allowed to refer to a sketch in a popular form, of what I conceive to have been the outline of the history of the Thames Basin, as I put it forward in a lecture last winter, a summary of which appeared in "Science Gossip" for May and June, 1891. I should like to draw particular attention to the many points of similarity between the conclusions I have arrived at as to the Tertiary history of this part of England, and those arrived at by Prof. Sacco of Turin, as to the Po Basin. (See "Bull. de la Soc. Belge de Géologie, etc., tome iv. 1890.)

"*False-bedding*," both on the larger scale and on that smaller scale known as "current-bedding" or "oblique lamination" is a phenomenon of extremely common occurrence in the sandy beds of both the Lower and Middle Group, testifying to the variations in strength and direction of the currents which laid the deposits down in their present position. Between the sand-beds (often current-bedded) there frequently occur, both in the Middle and Lower Group, thin seams, sometimes mere films, of pure *pipe-clay*, telling us of alternation of quiet conditions and the settling-down in still waters of the fine argillaceous materials, which, as every geologist knows, are capable of suspension in water for a considerable length of time. This alternation of conditions is so frequently and so strongly marked in the *interlaminated arrangement of clay and sand* in certain beds of the Middle Group, that, as a physical fact, it was one of the first among those, with which my earlier observations of these beds made me familiar, to suggest to my mind a deltaic origin for them. Some of the older geologists were startled three or four years ago, at my suggestion that the pipe-clay might be, in part at least, derived from the Chalk strata, which must have been exposed to subaërial erosion over considerable areas within the catchment-basin from which the waters were concentrated to the area in question. I was able to establish the probability of this by a very simple piece of laboratory work. A small quantity of the marly material of the Lower Chalk was pulverized and treated with very dilute acetic acid. The material was washed and re-washed with this, until no further escape of carbonic acid could be detected. The insoluble argillaceous residue settled down after suspension in water, to form a thin film of pure clay, similar in every way to the filmy deposits of pipe-clay which we meet with in the Bagshot Sands. What a feeble organic acid could do in that case might easily be done in the ordinary processes of nature, with sufficient time and the conditions prevailing in a deltaic area, by the action of the *humus acids*, which decaying vegetation furnishes. The facts here stated seem, I think, to justify my refusal to accept the presence of either current-bedding, or pipe-clay films, or of both together, as infallible tests of horizons, as has been persistently urged by one or two workers in the Bagshot Series. The fact established by more extended observations is that a pure massive clay deposit is found only in the Middle beds, and that the conditions favourable to its deposit were feebly anticipated in the upper horizons of the older fluviatile sands, and were feebly repeated in places in the earlier stages of deposition of the younger Upper Sands.

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[1] See Naumann-Zirkel: "Elemente der Mineralogie;" Leipzig (Engelmann), 1885. Also, Justus Roth's "Chem. und Allgem. Geol." p. 559.

In the Quart. Journ. of the Geol. Soc. for August, 1887, I have given many of the results of my studies in the Bagshots, not the least interesting being the discovery of Freshwater Diatoms in some of these beds. In a later number of the same Journal (May, 1888) I have pointed out that the prevalent rounded form of the grains of sand in the greenest beds points to their having suffered a vast amount of æolian attrition, in the shifting of sand-dunes by the wind, before they were deposited in the lagoons, in the same manner as is now going on on some parts of the shores of the Baltic. To this kind of evidence we may now add the frequent occurrence of thin beds and laminæ of very pure clay in the very heart of these green-earth beds, where they are most fully developed, telling us of the still waters of the deeper portions of these lagoons, never ruffled by the wildest storms, too deep as yet to allow of the growth of the vegetation which lined their margins and covered the intervening swamps. We can even in some cases, with the data now to hand, measure the rate of the thinning out of the green-sand series as well as of the Lower quartz-sands, and thus at the same time approximately map the original outlines of some of the lagoons, as well as measure roughly the amount of local and contemporaneous subsidence which the underlying clays suffered.[1]

In the former paper referred to (1887) I ventured to suggest a natural classification of the beds of the Bagshot Series of the London Basin into—

a). An *Upper Marine-estuarine Series*;

b). A *Lower Fresh-water Series* of riverine, delta, and lagoon origin; in the place of the more empirical division into Upper, Middle and Lower, which is of no importance except for cartography, and even there is often as misleading as not.

The fact that occasional fossiliferous bands or zones are met with, and that some of the forms bespeak a marine habitat, no more proves the marine origin of this complex of sands, green-earths, and clays than the marine shells found driven some miles inland by a great south-westerly gale in the Rhone Delta[2] prove the marine origin of its beds; it might as well be argued that the Coal-measures were a "marine series" because of the occurrence at certain horizons of the well-known "mussel-band," or even of occasional lines of real marine shells. Colonies of creatures of a more or less marine character doubtless established themselves here and there in the more saline parts of the lagoons, and in the Bagshot beds these are preserved usually as casts in the cemented sand; but in the rare cases in which actual shell-structures have been preserved, it is certainly true, as far as my observations have gone, that they are much "broken, worn, and even comminuted:" for one even tolerably perfect shell there are hundreds of fragments of shelly *débris*, speaking to us eloquently enough of their drifting inland from time to time from the outer marine area. Some of the little Oysters *O. flabellula*) found for example at Yateley, were so much abraded that it was only after comparing them with many forms in the Jermyn Street Museum (with Mr. Newton's kind help) that I could convince myself of their specific identity.

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[1] Perhaps the Norfolk Broads present some analogy to the conditions which prevailed in this old Tamisian estuary in later Eocene time.

[2] Described by Lyell in the "Principles."

THE UPPER SANDS.

Messrs. Gardner, Keeping, and Monckton, in a recent paper,[1] state that "the beds [of the Upper Bagshot], and what can still be recognized of their fauna, are such as might have been formed in an open sea of considerable depth." But this statement amounts to very little, because, so far as the fauna is concerned, there is nothing inconsistent with the view that the molluscan forms which they have tabulated might just as well have been left by creatures which inhabited a shallow salt-water estuary. This will, I think, be clear to any one who will take the trouble to work through their list with the aid of such a reliable work as Woodward's "Manual of the Mollusca." That they are right in correlating the Upper Sands of the London Basin with the Barton of the Hampshire Basin is very probable; indeed, my own studies, which have proceeded rather on physical and stratigraphical lines, have led me to the same conclusion as that at which they have arrived; namely, that the break postulated at the base of the Upper Sands is in reality very inconsiderable. So far from requiring any great length of time to convert this Eocene delta with its swamps and lagoons into a tidal arm of the sea, we know that such changes may take place without any great draft on the bank of geologic time, seeing that within a 1000 or 1500 years the swamps and lagoons of the Yssel, through which, Tacitus tells us, Germanicus led his forces against the immortal Hermann, have all disappeared beneath the waters of the Zuyder Zee; while several hundreds of square miles of Holland at the present day are only preserved from permanent submergence by artificial barriers. Of the comparative rapidity of this later subsidence of this Eocene area we have evidence in the strata themselves. It is only by such an encroachment of the sea that we can give a rational account of the Bagshot pebble-beds, which recent researches have established as an important fact of Bagshot stratigraphy. These beds vary in thickness from a few inches to five feet or more. They are composed of well-rolled flint-pebbles derived entirely from the Chalk strata, which must have enclosed this Eocene area of deposition on the south and the north-west. It may be assumed that no rivers, that could have drained this Chalk area in Eocene times, even when all allowance is made for its *quondam* extension, could have manufactured such vast quantities of rounded pebbles out of angular flint fragments as we find sealed up in the Bagshot Beds over a large extent of country in the Basin of the Thames. We must look, therefore, to the action of a tidal surf as the only efficient agency. We know by direct observation how the hardest rock-fragments are converted into smooth pebbles by grinding along a shore-line under the influence of tides and storms; and we have plenty of instances of the way in which such pebbles are piled up into 'Chesil-banks' along the seaward margins of deltas. Even the form of the pebbles themselves testifies to this as their true history; the discoid form which they frequently acquire (as may be seen on the coast of South Devon, at Weybourn on the Norfolk coast, or on the 'Chesil-bank' at Portland), being reproduced in the flint-pebbles of our Bagshot Beds. In one of the most massive pebble-beds the pebbles are so commonly of a smooth discoidal shape that I have seen numerous heaps of these picked out from the pebbles that have been used in making a new road.[1] Now when we recollect that the facts cited tell us of shore-action upon a Chalk shore-line, there is no difficulty in conceiving how the waters of the Eocene sea may have pursued their destructive work upon the Chalk of the east of England, as it extended in all probability at that time much further to the north and east.

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[1] See Q.J.G.S. vol. xliv. p. 616, 1888.

When the last great stage of subsidence of the area set in, the pebbly shingle accumulated in the way here indicated would be driven inland, strewn over the original delta, and swept in places along its margin into such shelves or banks of shingle as we actually find along the northern margin, as far as we have been able to trace it. Nor do we suppose that there was anything of a cataclysmic nature in this; for, though the most general distribution of pebbles is at the base of the Upper Sands, this change did not come on all at once, as we know from the fact that other and less widely distributed pebbly deposits occur mixed up with the green earthy sands of an earlier stage at their uppermost horizon. Again, of the 52 species of Mollusca given by the authors quoted above as found in the Upper Sands some deduction must be made on account of the very imperfect way in which they have been preserved (merely casts for the most part in sand cemented together with peroxide of iron); and of the residuum, as many as ten are represented by their *genera*, and two at least by their *species* in the preceding Middle Group. These facts seem to warn us against postulating any very considerable temporal break between the two series. That the most massive banks of pebbles are found towards the western portion of the area would seem to follow as a natural result of the narrowing of the area towards the west, and consequently greater driving power of the tides, as their velocity increased with the narrowing of the area over which they were driven.

It was this subsidence of the area into a marine estuary which no doubt furnished the sandy and muddy bottom on which most of its fauna passed their existence; nor do I think that there is any real scientific basis for the hypothesis that the Upper Sands were once as rich in fossils as the more clayey Barton beds of Hampshire. The hypothesis of 'decalcification' may be run too hard. We must be allowed to insist upon proof of the fact being given in any case before admitting it as an explanation. In the case before us we can understand perfectly well how atmospheric waters, charged with the humus acids furnished by the decay of forest-litter in this area of ancient forest-land have first taken up iron in the sands to form salts of the protoxide, and then, on coming into contact with the shells embedded in the sands, have by a simple chemical reaction or interchange of acids and bases substituted for the carbonate of lime carbonate of iron, to be subsequently broken up by the oxidation of the iron into the peroxide, which gives the pseudomorphic casts of the original shells.[1] I have not, after much study of the question, the slightest doubt that this is the true history of these 'irony casts'; and I think that the direct action of merely carbonated atmospheric waters has had very little to do with their production.

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[1] Pebbles of this form are frequently used for rough paving-work, in this part of the country, just as the great market-place of Nottingham is paved with Bunter pebbles collected from the drift of the Trent valley. The whole of the streets of Norwich were thus formerly paved with pebbles from the Boulder-clay and Drift.

In connexion with these Upper Sands space prevents me from adding more than to draw attention to the fact that there are I believe signs in places of their beds having been formed by the planing down of the sand-dunes of the earlier deltaic stage; the materials having been stored up to a large extent during the long period occupied by that stage, and only needing redistribution by tidal action to give us in part the present beds of the Upper Sands.

The *time* represented by these few hundred feet of strata, as measured by the maximum development of their continental equivalents, is seen to be very great; and the study of their physical history tells us that such a lengthened period of time was required for their formation. The two series of deltaic clay deposits (entirely unfossiliferous), with their intervening and intimately associated green earths, probably occupied by far the greater portion of it. Compared with the necessarily slow accumulation of materials which the physical study of these reveals to us, the deposition of the fluviatile sands which preceded them and of the marine-estuarine sands which succeeded them was probably what might almost be called a rapid process.

V.—ON THE BRITISH EARTHQUAKES OF 1889.[1]

By CHARLES DAVISON, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

(*Continued from page* 316.)

(PLATE X.[2])

3. BEN NEVIS EARTHQUAKE: MAY 22, 1889.

Time of occurrence, 13 h. 58 m.; Intensity, about IV. Epicentrum, probably not far from Ben Nevis.

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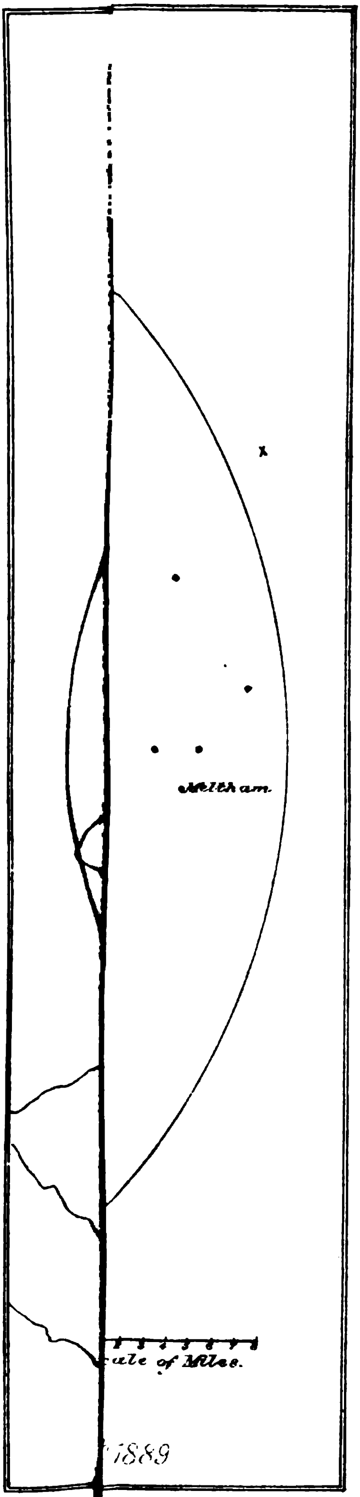
[1] There is nothing new in this. Dr. Alexis A. Julien explained in this way the formation of the irony casts in the "Northampton Sands," which are well known. See "Amer. Assoc. Adv. Sci." for 1879.

[2] Plate X. illustrates the area disturbed by the Lancashire Earthquake of February 10th, 1889, described in the GEOLOGICAL MAGAZINE for July, 1891, pp. 306–316, forming part 2 of this communication.



Wm Newman imp

I am indebted to Mr. R. T. Omond, Director of the Ben Nevis Observatory, for the only information I have been able to obtain with reference to this earthquake. "It was," he says, "sufficiently strong to make part of the wooden roof creak, but was, as far as I know, not noticed in any other part of the country." The few inquiries that I have been able to make confirm this remark, and I think we may therefore conclude that the epicentrum cannot have been very distant from Ben Nevis. The great fault, which crosses Scotland from Inverness in a south-westerly direction, passes at the surface within a short distance from Ben Nevis; and being, in other parts of its course, closely associated with recent earthquakes, may possibly, by a slip, have given rise to the Ben Nevis shock.

In connexion with this earthquake may be mentioned a slight shock felt on June 19, 1889, at 7h. 40m., at Invergarry, a place 26 miles N.E. of Ben Nevis, and also close to the same great line of fault. Mr. John Grant, of Invergarry, was kind enough to send me a note of this shock, and also a list of several others felt between Jan. 1, 1888, and Jan. 19, 1890. I have followed the rule laid down by the Swiss Seismological Commission, of not treating as undoubted earthquakes those which rest on the authority of one observer only; but, at the same time, I think it is evident, from the opportunities which Mr. Grant has had for these observations, that this is a somewhat exceptional case. I add here his list of the earthquakes felt at Invergarry during the year 1888, as it has an obvious bearing on the seismic history of the district:

1888.

Jan. 5, 5h. 30m., four vibrations, strong enough to shake lamps, dishes, etc. (Intensity IV.)

Feb. 2, 5h. 5m., one vibration, like the passing of a heavy carriage.[1]

Feb. 29, 20h. 10m., one vibration, like a carriage passing.

March 1, 9h. 15m., the same.

April 4, 9h. and 11h., like a light carriage passing.

May 20, 18h. 10m., the same.

July 3, 14h. 30m., the same.

Oct. 22, 13h. 25m., the same.

4. KINTYRE EARTHQUAKE: JULY 15, 1889.

Time of occurrence, about 18h.; Intensity, V. Epicentrum, about 3½ miles S.E. of Clachan.

Disturbed area.—I have only succeeded in obtaining records of this shock from eight places; but the information received from these and other places is sufficient to enable the boundary to be drawn with a fair approach to accuracy. Thus, the shock was not felt at Campbeltown or Southend, nor on the west side of the ridge of Gigha Island. In Arran, the Rev. J. Johnstone informs me, it "was felt from Pionmill right by the Crawhill and Lochranza, passing through the glen that enters Lochranza from Sannox."

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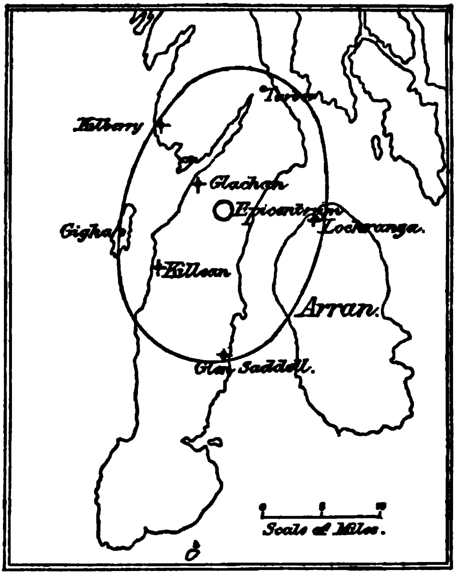
[1] This earthquake was felt over the greater part of northern Scotland.

The disturbed area is thus roughly elliptical; its longer axis, in a direction about N. 30° E. and S. 30° W., being about 25 miles long, and the shorter axis about 18 miles. The whole area disturbed, including that covered by the sea, is about 350 square miles. The boundary of the disturbed area corresponds to an isoseismal line of intensity IV.

Nature of the Shock.—From the few records I possess on this point, it would seem that the shock consisted of only one vibration; no tremulous motion, either before or after the shock, being noticed at any place.

Duration.—The estimates of the duration are fairly concordant. It is stated to have been not more than two to three seconds at Glen Saddell; several seconds at Kilberry; two seconds, or perhaps more, at Lochranza; and not more than four or five seconds at Gigha. But, as there was only one vibration noticed, it is probable that these estimates include also the duration of the sound that accompanied the shock.



Kintyre Earthquake: July 15.1889.

Intensity.—At Lochranza, the intensity must have been V. or nearly so. It was probably greater than IV. at Killean; and IV. at Glen Saddell, Kilberry, Clachan, and Gigha.

Sound-Phenomena.—So far as I can learn, the sound-area was approximately co-extensive with the disturbed area considered as bounded, as above stated, by an isoseismal of intensity IV. From Ardpatrick and Tarbert I have no particulars beyond the fact that the shock was felt at those places. But, at the other six places marked on the map, the characteristic earthquake-sounds were heard. They were compared to the movement of heavy articles of furniture overhead (Glen Saddell and Killean), the passage of heavy vehicles (Kilberry and Lochranza), a strong blast of wind up the chimney (Gigha), and a cartload of stones being suddenly emptied (Gigha). The sound is said to have accompanied the shock at Kilberry, and to have preceded it at Glen Saddell and Lochranza.

Position of the Epicentrum and Geological Relations.—The centre of the disturbed area is about 3½ miles S.E. of Clachan. That the earthquake can have had no connexion with the great southern boundary fault of the Highlands is evident from the distance of the epicentrum from the continuation of the line of this fault. Prof. C. Lapworth, F.R.S., has, however, been good enough to give me the following note on the possible geological relations of this earthquake.

"The geological structure of this district shows that between Loch Fyne and its prolongation, Loch Killisport, there is a band of slaty material more or less unaltered. A corresponding band occurs on the fringe of the Highland district, running from Stonehaven to Dunoon and Rothesay. Between these two well-marked lines of slate, lies a great area of gneiss. The relation of the gneissic rocks to the slaty rocks is disputed; by some it is suggested that the gneisses rise in an anticlinal form from below the schists; by others, that the gneisses lie on a synclinal formed of the slates. The apparent dips of the metamorphic strata make the latter interpretation the simpler and more probable one to geologists accustomed to lowland areas. If we recollect, however, that the Highlands are actually a denuded mountain complex, it becomes far more probable that this apparent synclinal is actually a fan-structure or inverted anticlinal, as suggested in my paper on "The Secret of the Highlands."[1] If this is the case, the slipping and movements caused by lateral pressure will take most effect along the two planes of contrary motion running midway between the crest of the main fold and its bounding synclines. Curiously enough, the line of direction of the axis of the disturbed area coincides precisely with the theoretical position of the southern zone of contrary movement, on the assumption that the gneisses form an inverted anticlinal."

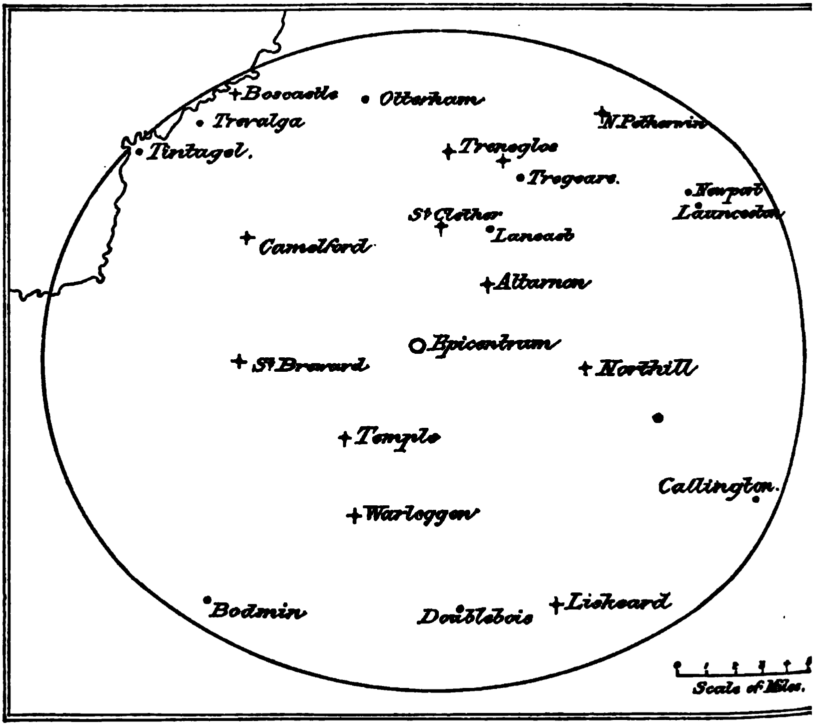
Authorities.—The only published account of the earthquake that I have met with is contained in the "Oban Times" for July 20; and I am indebted to the courtesy of the Editor of this paper for searching his files and sending me the extract referred to. For the greater part of the information on which the above account is founded, I have to thank the following gentlemen: the Revs. J. Johnstone (Lochranza, Arran), D. N. Macdonald (Killean), J. F. McKenzie (Gigha), and H. W. Strang (Campbeltown); Mr. R. A. Cavana (Gigha); and especially Mr. J. N. Macleod of Kintarbert and Saddell, without whose aid the account of this earthquake would have been much more imperfect than it is.

[1] Geol. Mag. Dec. II. Vol. X. pp. 120–8, 193–7, 337–44 (1883).

5. East Cornwall Earthquake: Oct. 7, 1889.

Time of occurrence, about 13h. 45m.; Intensity, IV. Epicentrum, about 2¾ miles S.W. of Altarnon.

Disturbed Area.—All the places, 24 in number, at which the earthquake is recorded as having been felt, are included within an area which is roughly elliptical in form. The larger axis, which runs nearly east and west, is about 25 miles in length, the shorter axis about 20 miles, and the whole area disturbed about 400 square miles. The curve bounding this area is an isoseismal of intensity IV.



E. Cornwall Earthquake: Oct 7 1889.

Nature of the Shock.—The accounts of the shock, though few in number, are sufficient to indicate roughly the way in which the nature of the shock varied throughout the disturbed area. We may divide the observations into two groups. In the first we have:

Altarnon: a distinct rumbling was heard, as if the chimney were on fire or a heavy waggon passing up the road; very little if any perceptible vibration.

North Hill: a sound heard as though something had struck the wall of the house, and "then the sound seemed to vibrate at the back."

St. Clether: like a distant peal of thunder or the passing of a very heavy loaded waggon; no tremors perceived.

Temple: like the rumbling of thunder for a few moments, followed by a tremulous motion.

Treneglos: a loud rumbling noise like thunder; no tremulous motion perceived.

With the exception of Laneast, from which I have no detailed account, these five places are nearer to the spot indicated as the epicentrum than any of the others from which records have been received. From this point, Altarnon is distant 2¾ miles, North Hill 5, St. Clether 4, Temple 4, and Treneglos 6¼ miles.

The second group includes places in the neighbourhood of the boundary of the disturbed area:

Bodmin: as if some person were walking with a heavy tread three or four steps overhead.

Boscastle: two distinct shocks are said to have been felt.

Liskeard: (1) as if a heavy substance were thrown violently on the floor of the adjoining room and also against the partition dividing the two rooms, tremulous movements before the shock; (2) one sudden crash like an explosion, no tremulous motion perceived.

North Petherwin: a slight vibration like that produced in a house by the passage of a heavy waggon.

St. Breward: like that produced by a cart passing along the road at the back of the house.

Warleggan: as if something very heavy had fallen in the house with great violence, followed by a tremulous motion.

From these accounts, we may conclude that, in the neighbourhood of the epicentrum, the sound-vibrations were most noticeable, but that these died out more rapidly towards the boundary of the disturbed area than the vibrations of longer period, and near the boundary the shock was felt as one or several thuds, or vibrations of much larger amplitude than those which preceded and followed them.

Duration.—The duration of the shock is variously estimated at from two to about twenty seconds. Thus, at Liskeard, according to one account, it is said to have been more than two seconds, according to another about fifteen seconds; a tremulous movement before the principal vibration being included in the latter estimate. Other observations give about 2 seconds at North Petherwin, about 3 at St. Clether, 3 or 4 at Temple, 4 or 5 at Warleggan, 10 to 20 at Treneglos, and 12 to 20 at St. Breward.

Intensity.—Throughout the disturbed area, the intensity seems to have been remarkably uniform, indicating probably a great depth of the seismic focus. According to the Rossi-Forel scale, the intensity was IV. at the following places: Bodmin, Camelford, Liskeard, Newport (near Launceston), St. Breward, Temple, Treneglos, Tresmere, and Trevalga. It may have been slightly greater than IV., though probably not as great as V., at Altarnon, St. Clether, and Warleggan: and perhaps slightly less than IV. at North Hill.

Sound-Phenomena.—The sounds accompanying the earthquake have been already alluded to: they form perhaps its most noteworthy features. They seem to have been of the usual description, being compared to thunder, to heavy waggons passing rapidly along adjoining roads, and to the roaring of a chimney on fire. At the following places the sound is said to have accompanied the shock: Camelford, St. Breward, St. Clether, Temple and Treneglose. It preceded the shock at North Petherwin, and perhaps also at North Hill and Tresmere. At Warleggan, the rumbling sound was heard just after the shock, "as if a waggon had run away down the hill outside our house: it increased in sound and then appeared to me like an express train going through a station. . . . . The rumbling ended quite abruptly." At Liskeard, it preceded the shock; but another correspondent at the same place informs me that it was heard both before and after the shock, both times very low, but rather louder after than before.

The earthquake-sounds were heard at all places from which I have detailed accounts. The sound area and the disturbed area may therefore have been coextensive, or nearly so. Further, since the sounds were the most notable part of the phenomenon near the epicentrum, and at a place like Liskeard near the boundary of the disturbed area were only heard by a few persons, we may conclude that the intensity of the sound diminished more rapidly than that of the shock as the distance from the epicentrum increases; and, consequently, that the sound-focus was nearer to the surface than the rest of the seismic focus.

Position of the Epicentrum and Geological Relations.—The epicentrum of the earthquake is about 2¾ miles S.W. of Altarnon, *i.e.* not far from the centre of the great granite boss which occupies so large a part of East Cornwall. It is also noteworthy that the duration of the shock was in some parts considerable, as much as 10 or 12 seconds, arguing probably a larger seismic focus than in any of the previous cases; further, that the longer axis of the disturbed area runs east and west, *i.e.* parallel to the direction of folding of the district. Though we may not at present be in a position to assign a definite origin to this earthquake, it seems at least probable that it had some connexion with the geological structure of the district, and that the forces which have combined in producing that structure have not yet ceased to act.

Authorities.—"St. Austell Weekly News," Oct. 12; "West Briton and Cornwall Advertiser" (Truro), Oct. 10; "Western Morning News" (Plymouth), Oct. 8.

The earthquake was but slightly noticed in the local press, and nearly all that is of value in the preceding account I owe to the kindness of the following ladies and gentlemen: the Revs. R. H. Boles (St. Breward), C. Bridgewater (St. Tudy), J. R. Browne (Bodmin and Temple), W. Jago (Bodmin), A. H. Malan (Altarnon), C. Olive (Warleggan), J. Partridge (St. Clether), T. B. Trentham (North Petherwin), Canon Vautier (St. Mabyn), T. Walters (Boyton), and T. Willing (North Hill); Mr. J. C. Chapman (Treneglose), Mrs. L. Davy (Tresmere), Miss F. E. Jenkin (Liskeard), Mr. W. E. Parsons (St. Breward), and Miss L. Thorne (Liskeard).

DOUBTFUL EARTHQUAKES.

1. *Invergarry*, June 19, 1889, 7h. 40m. (see p. 365).

2. *Little Rhondda Valley* (South Wales), June 22, 1889, about 22h. 30m.; intensity, V.

A shock, supposed to be that of an earthquake, was felt at this date in and near the Little Rhondda Valley. The area disturbed by it was very small, probably not more than a few miles in its greatest diameter. It was felt at Llwynypia, Pontygwaith, Tylorstown, Watts Town, Ynishir and Ystrad.

The disturbance, which lasted a second or two, consisted of one vibration, and at Ynishir is described as having been like the shock of a blasting explosion, but much stronger. It was accompanied by a deep rumbling noise, like distant thunder, at Llwynypia, Pontygwaith, and Watts Town. The intensity was IV. at Pontygwaith, but cannot have been less than V. at Llwynypia and Ynishir. The shock was felt by workmen underground in the Ynishir Steam Colliery, and in one or two other collieries in the adjoining district.

This is all the evidence I have been able to obtain, and I do not think it is sufficient to put beyond doubt the seismic origin of the shock. For so small a disturbed area, the intensity is unusually great, arguing a very small depth for the centre of disturbance; and, besides this, the mining operations of the district are being carried on so rapidly and extensively that, from time to time, considerable masses subside, occasionally, it is said, causing tremors very like those of an earthquake.

Authorities.—"Nature," vol. 40, p. 208; "South Wales Daily News" (Cardiff), June 24, 1889. For other information contained in the above account, I beg to thank Mr. W. Galloway, Mr. J. J. Thomas, of Ynishir, and Mr. R. R. Hood, of Gilfach.

3. *Lyme Regis*, July 5, 1889, between 23h. and 23h. 15m.

Noises were heard at intervals between the times stated. They "consisted of a distant rumble which grew nearer till at last the windows of the houses rattled and in some cases distinct vibrations of the houses were felt." They were probably not caused by the firing of guns at sea: and they may have been due to earthquakes, though the evidence is clearly incomplete.

This note is taken from a letter by Mr. A. R. Sharpe, in Nature, vol. 40, p. 294.

CONCLUSION.

With one possible exception (that of Ben Nevis), the earthquakes of 1889 are typical examples of British shocks—they occurred in districts where earthquakes are rarely felt, and their disturbed areas are circular or only slightly elliptical in form. Turning to a more distinctly seismic area, Switzerland for example, we find that the disturbed areas are often extremely elongated, the longer axes being parallel to those of the neighbouring Alpine chain; earthquakes are more frequent, their intensity, as a rule, is greater, and much larger areas are disturbed. Different stages in the geological history of a district are characterized by different kinds of earthquakes. The Alpine system is not yet old, fault-formation is still in progress, and the fault-slips are long and frequently recurring. In Great Britain, we meet with a later stage. Fault-formation in our seismic area is more advanced, and slipping takes place so slowly and over distances so short, that our earthquakes are rare and the areas disturbed by them more or less circular in form.

Every stage in the process, however, requires investigation, and that of which our British earthquakes are witness is certainly deserving of attentive study. Unattractive though it may be at first sight, the epoch immediately preceding the death of a mountain-chain, is at least as interesting to the geologist as the more vigorous periods of origin and growth.

ERRATA IN THE MAPS.

Edinburgh earthquake:	*For*	Costorphine,	*read*	Corstorphine.
	,,	Georgie,	,,	Gorgie.
	,,	Currieball,	,,	Curriehill.
Lancashire earthquake:	,,	Tongridge,	,,	Longridge.
	,,	Mihnrow,	,,	Milnrow.
	,,	Harwich,	,,	Horwich.
Kintyre earthquake:	,,	Tarber,	,,	Tarbert.
	,,	Glachan,	,,	Clachan.

In the map of the Lancashire earthquake, the outermost of the two smaller circles should have been a dotted line. In the map of the E. Cornwall earthquake, the spot between North Hill and Callington should be erased.

VI.—THE AGE OF THE HIMALAYAS.

By W. T. BLANFORD, LL.D., F.R.S., etc.

I REGRET that I cannot accept as unquestionable the evidence brought forward by my friend Mr. Howorth in favour of the recent elevation of other mountain ranges in Asia besides the Himalayas. I dealt with the latter alone, because I have a slight acquaintance with parts of them, and some knowledge of the observers whose opinions are quoted. But I argue from the known to the unknown, and if I find reason to reject the evidence on which Mr. Howorth relies to prove the absence of extensive glacial markings in the Himalayas, I am disposed to be sceptical as to that on which he founds his argument in the case of other ranges. I decline to be drawn into a discussion about the latter.

I quite agree in the improbability of the Himalayan ice having ever reached the Indo-Gangetic plain, but I think I have shown that this is not the question at issue. I cannot, however, help remarking that if I depended chiefly, as Tchihatcheff and Cotta appear to have done in the case of the Altai, on the presence or absence of erratics, I might come to a different conclusion, for there are unmistakable "erratics"—huge blocks believed to have come from the higher Himalayas—in the Northern Punjab.

I hope I do no injustice to Mr. Howorth's argument in placing it in this form: because the glaciers of the Alps in Pleistocene times extended some distance beyond the base of the mountains, those of the Himalayas, if they existed, should have done the same. Surely no one can contend that the glaciers of the Alps must descend to the sea-level at the present day because those of Greenland do so. But the difference in latitude between the Himalayas and the Alps is practically the same as that between the Alps and Greenland.

But, Mr. Howorth urges, there was a great sea in Central Asia in Pleistocene times, and consequently Himalayan ice would have transported glacial *débris* beyond the mountains. I dispute both the fact and the inference. Even if there was a greater ice-accumulation (and I think I have shown that there was), it does not at all follow that this would have reached plains, but little above the sea, within from 26 to 34 degrees of the Equator. With regard to the Central Asiatic sea, of course there was a considerable tract covered with water in late Tertiary and probably in Pleistocene times in the Caspian and Aral area. But this area was I believe then, as it is now, cut off from Tibet and the Himalayas by the great ranges extending from the Pamir through the Thian-Shan to the Altai, and surrounding Eastern Turkestan on the West and North. As to great lakes having occupied the depressions of Eastern Turkestan, the Gobi, etc., I can only say that I once mistook similar plains in Persia for lake-basins, and have seen reason to believe I was in error. The occurrence of salt lakes and salt plains merely indicates the absence of drainage, and is by itself no proof of the former occupation of any area by the sea. The horizontal or nearly horizontal beds supposed by many observers to be marine or lacustrine are probably similar to those found throughout the drier regions of Central Asia, and due purely to the wash of detritus from the hills into the plains by rain and melting snow, where the whole rainfall is insufficient to form rivers and to wash away the accumulations, all the water evaporating within the plains themselves. With the coarser beds fine Eolian deposits are associated. I do not wish to appear dogmatic, but after having had better opportunities than fall to the lot of most European geologists of studying the subject, I am unable to attach any value to the evidence brought forward, although I fully acknowledge how strong that evidence appears at first sight by admitting that I was at one time led away by it.

Of the two quotations from my contributions to the Manual of Indian Geology that are adduced as supporting Mr. Howorth's views, the first, and the first part of the second, do not appear to me at all favourable to his theory. Surely, to say that "a movement has been distributed over the Tertiary and post-Tertiary period, and a great portion is of post-Pliocene date," is not the same as to say that the whole movement, or even the greater part of the movement, is post-Pliocene; nor is the argument that "at the close of the Miocene period no such mountain barrier as exists at present separated the Indian Peninsula from Central Asia" equivalent to saying that the barrier was wanting at the close of the Pliocene.

The citation of my remarks as to the post-Siwalik elevation of the Tibetan plateau, however, is a fair hit, and shows how thoroughly Mr. Howorth has collected the testimony in favour of his views, though he appears to have overlooked the footnote (on p. 586) appended to the words quoted, and, to some extent, qualifying the opinion recorded, as it called attention to the greater area once occupied by Himalayan ice. The explanation, however, of my having published what I now think was probably an incorrect view in 1879, is that at that time I had only the evidence concerning the fossil fauna of Hundes that was obtained by Falconer and Strachey. When Lydekker, in 1881, found that one of the best-preserved Hundes fossils was a skull of *Pantholops*, an Antelope confined to the Tibetan plateau, and only living at high elevations, the whole evidence was materially changed. The question now is, whether it is more likely that *Pantholops* inhabited a low level or an unknown Rhinoceros a high one. Of course, where Yaks can find food, there is no reason why a Rhinoceros should not obtain subsistence.

I must again call attention to the fact that far from attempting to go into the whole evidence as to the elevation of the Himalayas, I merely selected two items, one to prove the insufficiency of the evidence brought forward by Mr. Howorth, the other to show the facts which he had overlooked, both items belonging to one, and, in my opinion, by no means the most important part of the geological evidence. Merely to show how wide the question is, I should like for once to "forsake the happy hunting grounds of Geology for those of Zoology," and to call attention to a fact which to my mind is sufficient by itself to disprove a subrecent origin of the Tibetan highlands.

Throughout the great region generally known as Palæarctic, there is no tract of country of the same extent that contains as many peculiar forms of animal life as Tibet. Amongst Mammals alone there are the genera *Pantholops*, *Nectogale* and *Eupetaurus*, and probably *Æluropus* and *Budorcas*, together with the Yak, two kinds of wild Sheep, a Gazelle, two Hares, several *Lagomys*, at least three Marmots, and several Voles. I must say that it is to me incredible that this peculiarly specialized fauna can have been differentiated since Pleistocene times, and very improbable that it can have entirely developed since the Pliocene period. So high a degree of specialization points to a long continuance of the peculiar conditions that still prevail.

Of the two statements of mine that are traversed by Mr. Howorth, one is of course a matter of opinion; upon the other it will I think be found that my information was correct. Mr. Howorth says that Mr. Lydekker formerly classed the Hundes fossils as Pliocene, but subsequently adopted the opinion, which he still holds, that the beds are post-Tertiary. Mr. Lydekker's assignment of a Pleistocene age to the beds in question dates from 1881 (Rec. G.S.I. vol. xiv. p. 158); but in 1886 (Cat. Foss. Mam. Brit. Mus. vol. iii. p. 158) and in 1887 (Rec. G.S.I. vol. xx. p. 54) he has stated that he is now inclined to regard the beds as Newer Pliocene.

It is useless, I fear, to discuss the other statement traversed, whether the contours of the Himalayas are due to freshwater denudation; and we must continue to differ. But I must say that I still think a personal acquaintance with the Himalayas would give a very different idea from photographs and drawings of picturesque bits. The splintered precipices referred to by Mr. Howorth are probably due to the effects of frost; and however common in the higher Himalayas, especially where glaciers exist now, or existed formerly, are not, I think, prevalent in the lower valleys. If it be transcendentalism to refer to the denuding action of rain and streams, valleys and ridges which, however gigantic, are the exact counterparts in form of those seen in a bank of clay after exposure to a season's rain, how should the reference of such contours to an unknown agency be fitly designated?

REVIEWS.

I.—Dr. Anton Fritsch on Palæozoic Elasmobranch Fishes.

"Fauna der Gaskohle und der Kalksteine der Permformation Böhmens." By Dr. Anton Fritsch. Band II. Heft IV. (pp. 93–114, Pls. 80*b*.–90); Band III. Heft I. (pp. 1–48, Pls. 91–102). 4to. (Prague, 1889–90.)

THE two latest parts of Dr. Fritsch's well-known work on the Permian Vertebrata of Bohemia form one of the most important contributions to our knowledge of the Palæozoic Elasmobranchs that have hitherto appeared. A fine Dipnoan skeleton is first described and figured under the name of *Ctenodus tardus*, as a supplement to the preceding part; but with the exception of the two pages and one plate devoted to this, the whole of the instalment is occupied with what the author terms the "Ordnung Selachii." Following ancient custom, the Holocephali are included in the group thus designated in the preliminary remarks; and, for the purposes of the memoir, the Plagiostomi are subdivided into the four "tribes" of Squalides, Xenacanthides, Acanthodides, and Rajides.

Of the "Squalides," or ordinary Sharks, only a single tooth has yet been found in the Bohemian Gas-coal. This tooth is hybodont in form, and receives the name of *Hybodus vestitus*. The determination, however, falls under the same category as the author's now-abandoned statement concerning the occurrence of a Permian species of *Ceratodus*; and it by no means proves the downward range of the Mesozoic genus *Hybodus* into the Palæozoic formations. As in the case of the Dipnoi and the Pleuracanths, detached teeth of the hybodont Sharks are worthless for generic determination.

Of the "Xenacanthides" only the single family of "Xenacanthidæ" is recognized; but why the author should depart from the ordinary system of nomenclature, and not derive the title of this family from its type-genus *Pleuracanthus*, it is difficult to understand. The three genera *Orthacanthus*, *Pleuracanthus*, and *Xenacanthus* are regarded as quite distinct, and re-defined upon the basis of the new Bohemian

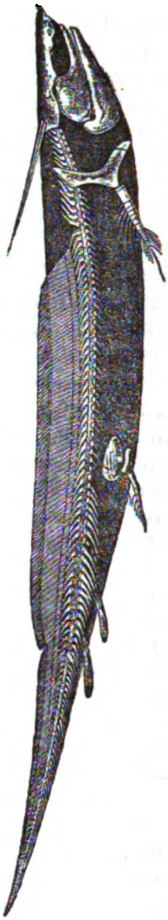


Fig. 1.—Restoration of *Pleuracanthus parallelus*, Fritsch.

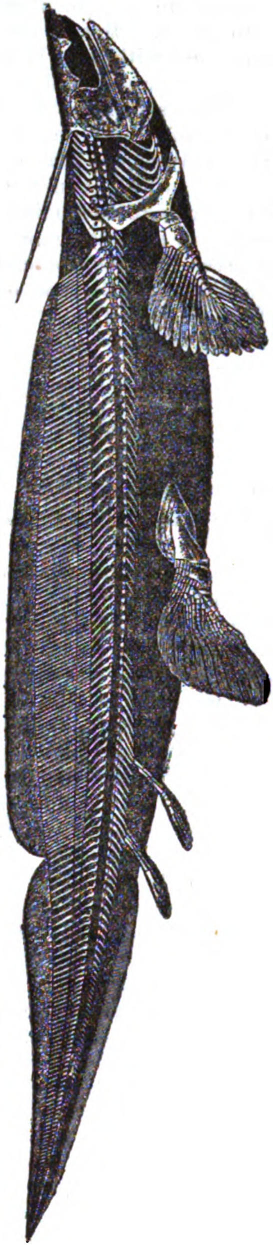


Fig. 2.—Restoration of *Xenacanthus Decheni*, Goldf. sp.

specimens. The characters of the teeth, dorsal spine, of the denticles upon the branchial arches, and of the pectoral fins, are quoted as diagnostic; while of *Pleuracanthus* and *Xenacanthus* the materials suffice to justify the two restorations reproduced through the courtesy of Dr. Fritsch, on the opposite page.

As in Britain, *Orthocanthus* is only known in Bohemia from comparatively fragmentary remains. To it are referred (i.) rounded spines having posteriorly placed denticles; (ii.) large teeth with a relatively small median denticle; (iii.) clustered branchial tubercles; and (iv.) long pointed pectoral fins without horny fin-rays. Four Bohemian Permian species are determined, and a fifth (*O. senkenbergianus*) is briefly described from the corresponding horizon of Lebach. Even yet, however, the genus is far from being satisfactorily diagnosed; and with reference to the dentition, we venture to think that it would not be difficult to cite more than one British specimen proving the occurrence in one and the same mouth of the two forms of teeth which Dr. Fritsch regards as characteristic of *Orthacanthus* and *Pleuracanthus* respectively.

Some brief remarks on three undetermined Ichthyodorulites follow the account of *Orthacanthus*, and bear the newly-applied generic names of *Tubulacanthus*, *Brachiacanthus*, and *Platyacanthus*. These names may be only provisional, but we would remark that the first is an inadmissible hybrid, while the two latter are pre-occupied.

The sections devoted to *Pleuracanthus* and *Xenacanthus*, with the general conclusions resulting from the study of these types, make a most important advance in our knowledge of the group to which they belong. As will be observed in the author's restored figures of the two genera (Figs. 1, 2), *Pleuracanthus* is a somewhat more slender fish than *Xenacanthus*, and differs considerably in the character of the fins; in the former genus there are no dermal skeletal parts and the pectoral fin is much elongated, whereas in the latter genus dermal fin-rays are conspicuous and the pectoral is comparatively short and broad. The cavity in the dorsal spine is also described as relatively smaller in *Pleuracanthus* than in *Xenacanthus*. Four Bohemian species of the former genus are determined, and short notes follow on the German *P. sessilis* and the French *P. Gaudryi*; while of *Xenacanthus* the type-species *X. Decheni* is regarded as the sole known representative. Numerous detailed descriptions with beautiful figures of various parts of the skeleton appear in connection with the several species; and the systematic work concludes with a chapter of general observations on the organization of the Pleuracanth fishes as now known.

The results are briefly summarized in the following statement: The skin in these fishes was destitute of scales; the cartilaginous skeleton exhibits everywhere a granular calcification; the skull consists of a continuous piece of cartilage, without investing membrane bones; the nuchal spine is fixed upon a papilla of the cranial roof, and is not connected with a fin; the axial skeleton of the trunk is notochordal, with a calcification of the central fibres; the neural arches are strongly developed, and in two genera there are intercalary cartilages; there are seven branchial arches; the shoulder-girdle is comparable to a branchial arch; the paired fins must have developed from a series of parallel rays, and the joints of the axial rod have arisen partly by thickening, partly by the fusion of several adjoining rays; there are no pelvic elements, the so-called "pelvis" being the basipterygium; the claspers of old males are similar to those of existing Sharks, and there are also the same developments in aged females; the oval eggs have a strong capsule.

In conclusion, Dr. Fritsch finds the nearest living allies of the Pleuracanth fishes in the remarkable family of Notidanidæ, and adds the inevitable "Stammbaum" to show the ancestral position in which he would place them. Few who closely study the evidence will fail to be convinced of the reasonableness of this arrangement; and the majority will doubtless be disposed to follow the Professor in his most interesting theoretical excursus on the origin and development of the paired fins. Recent discoveries compel us to add only one word of caution, namely, that it is rash to assume there were no groups higher than the so-called "Urfische" retaining the primitive parallel disposition of the cartilaginous rays in the paired fins. The fishes with a Cladodont dentition lately made known by Dr. Newberry from the Lower Carboniferous of Ohio under the names of *Cladodus Kepleri* and *C. Fyleri*, seem to have been true Elasmobranchs; but their pectoral fins are not "archipterygial" in the sense of Gegenbaur's terminology, and appear to consist merely of segmented parallel bars. However this may be, the recent rapid advances in our knowledge of the palæontology of the Palæozoic Elasmobranchs must be a source of much gratification to all who are interested in the evolution of the vertebrata; and to no one are we indebted more than to Dr. Anton Fritsch for enduring contributions to the subject. A. S. W.

II.—CATALOGUE OF THE FOSSIL BIRDS IN THE BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, S.W. BY RICHARD LYDEKKER, B.A., F.Z.S., F.G.S. (London, 1891.) Printed by order of the Trustees, and sold by Kegan Paul, Trench, Trübner & Co. 8vo. pp. i–xxviii, and 368, with 75 Woodcuts.

MR. LYDEKKER has earned the hearty thanks of all those who are interested in the palæontological history of the higher Vertebrates, by the valuable series of Catalogues of the Fossil Mammalia, Aves, Reptilia, and Amphibia which he has prepared, under the auspices of the Trustees of the British Museum (Natural History), which form ten separate parts or volumes, containing 3119 pages of text illustrated by 537 woodcuts. The earlier published volumes have already been noticed in this MAGAZINE, and we now have much pleasure in drawing attention to the final volume on the Fossil Birds, which has just been completed. If we except the Amphibia, the class Aves forms the smallest group of Vertebrates known in a fossil state; yet the number of living species exceeds 8000. Thirty-five years ago, it appeared as if the hope of attaining a knowledge of the ancestry of Fossil Birds was destined never to be gratified. But in 1861 a split slab of Lithographic Limestone was discovered at Eichstädt near Solenhofen, in Bavaria, in the Lower Kimeridgian formation, showing a nearly entire skeleton and impressions of the feathers of what was at first supposed to be a Reptile, but afterwards proved to be a remarkable long-tailed Bird, with twenty slender caudal vertebræ, each joint having a pair of feathers, one feather on each side. Twenty years later, a second specimen was discovered, identical with that described by Prof. Owen in 1862, but in some respects more complete, from which we learn that the jaws were armed with from ten to twelve teeth in the pre-maxillary border on each side, and three or more teeth in the lower jaw also; the teeth were conical and apparently planted in distinct alveoli. The three metacarpals and the phalanges of the fingers were free and were armed with strong recurved claws like those of a Lizard's fore-limb. This singular creature is at present the earliest, as it is also the most generalized bird with which we are acquainted; the sternum was well developed, and probably provided with a carina: indeed, from the characters of both the fore- and hind-limbs, we are justified in concluding that *Archæopteryx* was a perching, flying, Carinate type of Bird; it is the only representative of a distinct order, the SAURURÆ.

After another interval of ten years, two other types of toothed Birds were discovered by Professor Marsh in North America: one, the *Ichthyornis*, being a bird of powerful flight, with biconcave vertebræ; the other, *Hesperornis*, had a perfectly flat sternum, and was a large flightless aquatic Bird, probably resembling the Loons and Grebes in structure. These American birds, however, are from the Upper Cretaceous of Kansas, and, although of Secondary age, are much younger, and more specialized types than the *Archæopteryx*, which is of Upper Jurassic age.

Previous to these discoveries it had been supposed that the great group of running Birds, such as the Ostrich, Rhea, Emu, Cassowary, and Apteryx, represented the earliest types known; and seeing also that these Ratite, or raft-breasted flightless birds, have been found in a fossil state in England, France, India, Madagascar, New Zealand, Australia, and America, it was only natural to connect them with the still earlier discovery of Bird-like, bipedal impressions met with so abundantly upon the slabs of Triassic sandstone in the Connecticut Valley. These are now, however, commonly attributed to the huge Dinosaurian reptiles, whose remains have of late years been met with, both in N. America and in Europe, many of which evidently progressed upon their hind-legs only, and, having the same number of toe-bones as a bird, might have left similar foot-prints.

Of the other early remains of Birds known in a fossil state, by far the greater part are in an extremely fragmentary condition. Thus the *Enaliornis Barretti*, from the Cambridge Greensand, is founded upon an isolated fragmentary bone, the tarso-metatarsus. The *Odontopteryx toliapica* is founded on an imperfect skull from the London Clay of Sheppey, was considerably larger than that of a Solan Goose, which had the margins of the bones of both the upper and lower jaws coarsely serrated, and was no doubt also a large fish-eating Bird. Numerous remains of carinate Birds are represented in the Collection by detached bones from various localities and deposits, all of Tertiary age, and many of them referred to existing genera. The Great Auk (*Alca impennis*) is recorded from a guano deposit on Funk Island off the coast of Newfoundland; nearly all the bones with the exception of the phalanges are preserved; this is one of a dozen or more individuals found by Professor John Milne, F.R.S.

By far the most important part of the Collection, if we except the *Archæopteryx*, consists of the remains of the Ratite Birds, the *Æpyornis* of Madagascar being represented by two species, namely, *Æ. maximus*, casts of the femur, the tibio-tarsus, and the tarso-metatarsal bones, reproduced from types in the Paris Museum; the shaft of an actual bone, and an entire egg, 36 inches in longest circumference by 30·3 inches in girth; and *Æ. medius*, an egg, 30·3 inches in longest circumference, and 26·3 inches in girth.

The Indian Ostrich (*Struthio Asiaticus*), from the Pliocene of the Siwalik Hills, is represented by a conjoined mass of bones, comprising nine cervical vertebræ in natural juxtaposition, some imperfect bones of the wing, and the distal portion of the right tarso-metatarsus, together with the greater portion of the proximal phalangeal of the third digit in apposition with the latter. The *Dasornis Londiniensis* is only known by the cranium from the London Clay of Sheppey; but taken in connexion with the discovery of the limb-bones of another Struthious Bird, the *Gastornis Klaasseni*, in the Lower Eocene of Croydon, Surrey, we may conclude that Ostrich-like Birds lived in this country, and also in France and Belgium, in Eocene times. Of the great flightless birds of New Zealand, no fewer than six skeletons have been set up in the Gallery, representing at least five species; there is also a very large collection of detached bones referred to some twenty different species, all described by Prof. Owen. Some of these remains are so recent as to be still covered with dried skin and traces of feathers, showing that their extermination in those islands must have been of very modern date, and no doubt due to the hand of man.

Owen's genus *Dinornis*, we observe, has been subdivided by Lydekker into five genera; but we venture to question the desirability of this course, seeing how great is the individual diversity presented by the skeletons of these large running Birds; we incline rather to the view that they are the result of local variation produced by scarcity or abundance of food and the nature of their habitat; even difference of sex may account for size and robustness in individuals.

Whilst on the subject of nomenclature, we would also question the right to substitute H. von Meyer's specific name *lithographica* for *Archæopteryx macrura*, the latter name having been given to the original skeleton of the long-tailed Bird from Solenhofen by Owen, whereas Meyer's name was only applied to a detached feather of *some Bird* found in the same deposit a year or two previously. The only justification which we can conceive for this act, is that of the old proverb, that "Birds of a *feather* flock together." But the evidence of identity is by no means conclusive, and it seems hard, therefore, on Sir Richard Owen to wipe out his specific name with a *feather*, he having been the original describer of the almost entire skeleton.

Too much praise cannot be accorded to the Trustees of the British Museum, Natural History, for authorizing the publication of the long series of Catalogues of Recent and Fossil forms, in the Collections under their control, and we earnestly trust that the work may be continued until all the groups, both of Vertebrate and Invertebrate life, have been similarly recorded and illustrated.

III.—Mr. G. A. Boulenger on Extinct Reptilia.[1]

MR. BOULENGER contributes three papers of much palæontological interest to the June number of the Proceedings of the Zoological Society. The first deals with some fragmentary Eocene Chelonian remains; the second and third relate to taxonomic questions of wide importance.

During an examination of the reptilian fossils in the Museum of the Royal College of Surgeons, Mr. Boulenger met with a skull of *Trionyx*, apparently from the well-known Upper Eocene formation of Hordwell Cliff, and, if so, proving that the species represented is a typical member of the genus. The skull much resembles that of the existing *T. hurum*, and it is provisionally referred to *T. planus* (Owen), of which the shell is also closely paralleled by that of the recent species just mentioned. A Sheppey fossil in the same collection, described by Owen as "the lower or distal end of the tympanic bone of the *Crocodilus toliapicus*," is shown to be the proximal end of the left humerus of an Athecan Turtle, evidently *Eosphargis gigas*; while of two other fossils referred by Owen to the same "Crocodile" the so-called "portion of the left ramus of the lower jaw" is stated to be part of a scapula of *Eosphargis*, and "another portion of the right ramus of the lower jaw" truly belongs to a Liassic Plesiosaurian. Incidentally it is pointed out, that no species of the genus *Crocodilus* occurs in the Eocene, the so-called *C. Spenceri* being referable to *Diplocynodon*.

A study of the osteology of *Heloderma* and an attempt to determine its systematic position, lead Mr. Boulenger to express his views upon the classification of the order Squamata. Referring only to the structure of the vertebral column and limbs the following table of diagnoses is given:—

Order Squamata.

A. Pectoral arch or its rudiments present. Caudal hypapophyses forming chevrons.
Suborder I. *Dolichosauria.* 15–17 cervical vertebræ. Extremities archaic, *i.e.* approaching the Batrachian type.

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[1] "On Some Chelonian Remains preserved in the Museum of the Royal College of Surgeons," Proc. Zool. Soc. 1891, pp. 4–8, figs. 1–6.

"Notes on the Osteology of *Heloderma horridum* and *H. suspectum*, with Remarks on the Systematic Position of the Helodermatidæ and on the Vertebræ of the Lacertilia," *ibid.* pp. 109–118, figs. 1–6.

"On British Remains of *Homœosaurus*, with Remarks on the Classification of the Rhynchocephalia," *ibid.* pp. 167–172, figs. 1, 2.

Suborder II. *Pythonomorpha.* 9 or 10 cervical vertebræ. Extremities paddle-shaped, with hyperphalangy.
Suborder III. *Lacertilia.* 8 or 9 cervical vertebræ. Fibula reduced proximally; fifth metatarsal reduced in length and strongly modified.
Suborder IV. *Rhiptoglossa.* 5 cervical vertebræ. Extremities pincer-shaped; all the metatarsals reduced in length and strongly modified.
B. No trace of a pectoral arch. Caudal hypapophyses disconnected distally.
Suborder V. *Ophidia.*

Figures of the hind limb are added, the so-called *Hydrosaurus lesinensis* of the Cretaceous being selected as a typical representative of *Dolichosaurus.*

The left mandibular ramus of a small Rhynchocephalian reptile, also in the Museum of the Royal College of Surgeons, forms the text of Mr. Boulenger's third contribution. An examination of the matrix suggests that the specimen was probably obtained from the Lower Oolites of Wiltshire; and the left maxilla of a nearly similar reptile, from the Purbeck Beds of Swanage, is recorded as having been recently acquired by the British Museum. These fossils are believed to be referable to *Homœosaurus*, and the first is described and figured as the type of a new species, *H. major.* To the same species is also assigned a mandible from the Kimmeridgian of Hanover described by Struckmann in the Zeitschr. deutsch. geol. Ges. vol. xxv. p. 249, pl. vii. Some remarks on the systematic position of *Homœosaurus* follow; and after several critical observations in regard to the non-diagnostic character of most of the existing definitions of the Rhynchocephalia and the component families of the order, the following revised table is appended:—

Order RHYNCHOCEPHALIA.

Suborder I. PROTEROSAURIA. Each transverse segment of the plastron composed of numerous pieces. Pubis and ischium plate-like. Fifth metatarsal not modified.

Vertebræ conically excavated at either end, with persistent notochord, all with intervertebral hypapophyses; limb-bones without condyles; humerus with entepicondylar foramen. . . . . 1. *Palæohatteriidæ.*

Vertebræ fully ossified, cervicals opisthocœlous, dorsals biconcave; no hypapophyses between the dorsal vertebræ; limb-bones with condyles; humerus with entepicondylar foramen or groove. . . . . 2. *Proterosauridæ.*

Suborder II. RHYNCHOCEPHALIA VERA. Each transverse segment of the plastron composed of three pieces, a median angulate and a pair of lateral. Pubis and ischium elongate, and fifth metatarsal modified, as in the Lacertilia.

A. Nasal openings distinct. Mandible with coronoid process, the rami not united by suture. Vertebræ deeply biconcave.

Humerus with ectepicondylar and entepicondylar foramen; ribs with uncinate processes; all the vertebræ with intercentral hypapophyses. 3. *Hatteriidæ.*

Humerus with entepicondylar foramen; ribs without uncinate processes; no hypapophyses between the dorsal vertebræ. . . . . 4. *Homœosauridæ.*

B. Nasal opening single. Mandible without coronoid process, the rami united in a solid symphysis. Vertebræ fully ossified, feebly biconcave; no hypapophyses between the dorsal vertebræ. Humerus with ectepicondylar foramen or groove.

Snout short, ending in a beak. . . . . 5. *Rhynchosauridæ.*

Snout crocodilian in shape, with toothed premaxillaries. . . . .
6. *Champsosauridæ.*

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

June 10, 1891.—Sir Archibald Geikie, LL.D., F.R.S., President, in the Chair.

A Special General Meeting was held at 7·45 P.M., before the Ordinary General Meeting, at which the following resolution was proposed by Dr. **EVANS**, seconded by Mr. **BAUERMAN**, and carried unanimously:—That the Society approve of the recommendation of Council that Mr. Isaac Charlton, the House Steward, on his retirement, after fifty years' service, be granted a pension of £70 per annum for life.

Before the commencement of the general business, Prof. **BLAKE** rose, on behalf of those present at the meeting, to congratulate the President on the honour that it had pleased Her Majesty to confer upon him. No one who knew him could fail to appreciate how thoroughly it was deserved; and the Geological Society would doubtless feel also the honour conferred on their science in the person of their President and the Head of the Geological Survey of the United Kingdom.

The **PRESIDENT** referred to the services of the late Dr. Duncan, and suggested that in the name of the Society a message of cordial sympathy should be sent to Mrs. Duncan on the great loss which had befallen her. This proposal was approved of by the Fellows present; and the **SECRETARY** was requested to communicate with Mrs. Duncan.

The following communications were read:—

1. "Note on some Recent Excavations in the Wellington College district." By the Rev. A. Irving, B.A., D.Sc., F.G.S.

This paper furnishes new facts of Bagshot stratigraphy obtained from open sections since the author's last paper was read on Nov. 12th, 1890. The whole sequence of the beds, as given in the published section of the College Well, has now been verified at their respective outcrops; percentages of clay in the beds laid open in excavations in March last along the critical portion of the ground are given as results of mechanical analyses of samples of them; and the northerly attenuation of the green-earth series and of the quartz-sand series is reduced to a question of mere measurement, for which the requisite data are now to hand.

The author claims to have demonstrated that the mapping of the Geological Survey contradicts itself; that later workers in adopting this as the basis of their work along the S.E. Railway have fallen into serious error; and that a complete contradiction is given by the facts to the adverse criticisms offered on his corrected section along the railway, which was exhibited in November last, and is reproduced for the present paper.

2. "Notes on some Post-Tertiary Marine Deposits on the South Coast of England." By Alfred Bell, Esq. Communicated by R. Etheridge, Esq., F.R.S., F.G.S.

The author's object in this paper is to trace the successive stages in the development of the present coast of the north side of the English Channel, and to ascertain the sources of the diversified faunas.

The first traces of marine action on the South Coast in Post-Tertiary times are found on the foreshore in Bracklesham Bay. The author's reading of the section is somewhat different from that of the late Mr. Godwin-Austen; and he divides the marine series into (1) an estuarine clay with Mollusca common to estuarine flats; (2) a compact hard mud; and (3) a bed of fine sandy silt with many organisms. These beds indicate a change from estuarine to deep-water conditions. A full list of the Selsey fossils is given, including, amongst other animals, upwards of 200 Mollusca. Of 35 species of Mollusca not now living in Britain, the majority exist in Lusitanian, Mediterranean, or African waters; furthermore, nearly 45 per cent. of the Mollusca are common to the older Crags of the Eastern counties. The author considers the fauna of the Portland Bill shell-beds to indicate the further opening of the Channel subsequent to the formation of the Severn Straits, and believes that this fauna represents the deposits wanting between the Selsey mud-deposits and the erratic blocks which, according to him, overlie the mud; these Portland shells indicate an intermediate temperature "rather southern than northern" according to Dr. Gwyn Jeffreys.

In conclusion, details concerning still newer beds are given, and lists of fossils found therein; and the author observes that there is no evidence to show when the English Channel finally opened up, beyond the suggestion of Mr. Godwin-Austen that, if the Sangatte beds and the Coombe Rock are of the same period, it must have taken place after their formation.

CORRESPONDENCE.

PFAFF'S "ALLGEMEINE GEOLOGIE."

Sir,—By an inadvertence I have, in quoting Dr. Pfaff's work on p. 301 of the July Number of the Geol. Mag. confused the title with that of a well-known work by Justus Roth. The true title of Pfaff's work referred to is *Allgemeine Geologie als exacte Wissenschaft.* I shall be greatly obliged if you can afford space for this correction in the forthcoming Number.

A. Irving.

MOLARS OF PERISSODACTYLA;—A CORRECTION.

Sir,—In my notice on this subject on page 321, line 15 from top, I have inadvertently written *crotchet* instead of *anti-crotchet.*

R. Lydekker.

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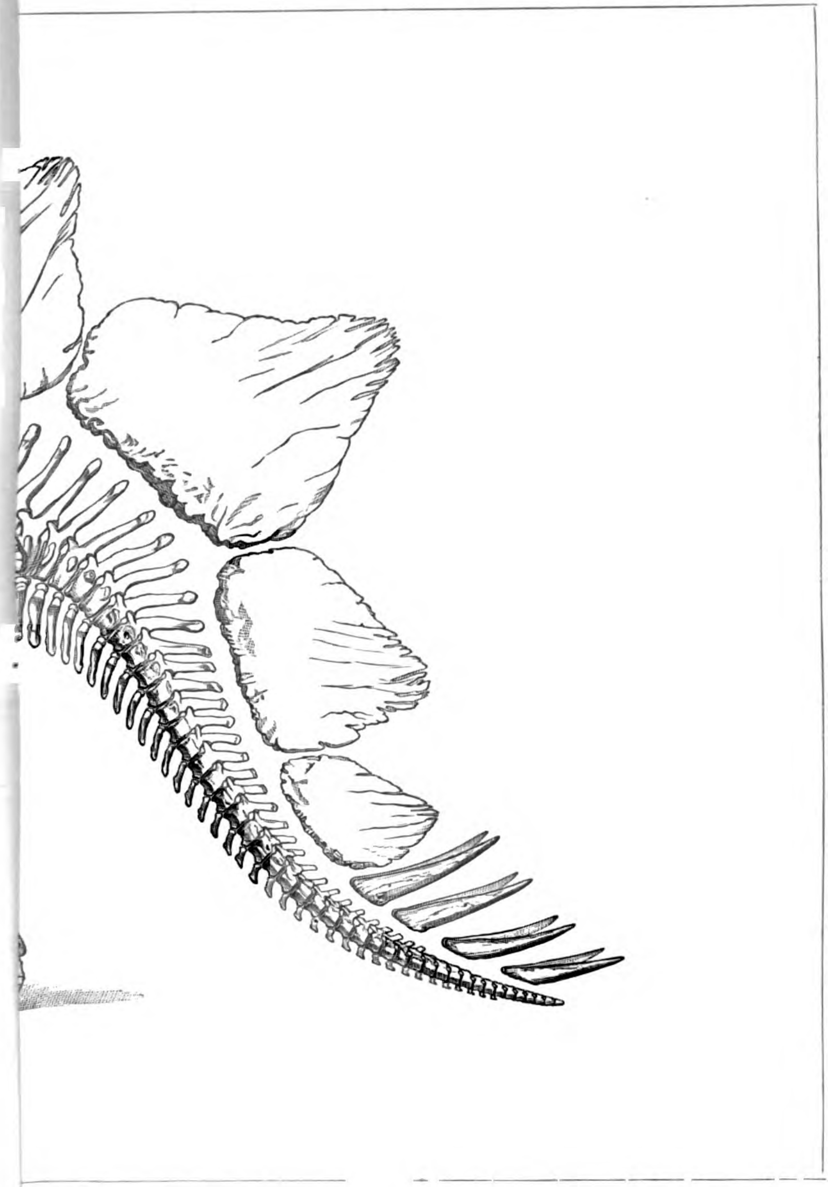

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THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VIII.

No. IX.—SEPTEMBER, 1891.

ORIGINAL ARTICLES.

I.—Restoration of Stegosaurus.

By Prof. O. C. Marsh, Ph.D., LL.D., F.G.S., etc.

(PLATE XI.)

IN the American Journal of Science in 1877, the writer described a remarkable extinct reptile from Colorado, under the name *Stegosaurus armatus*,[1] and later a much more perfect specimen of another species, *Stegosaurus ungulatus*, from essentially the same horizon, in the Jurassic of Wyoming.[2] The latter specimen was in fine preservation, and the more important parts of the skull and skeleton, and especially of the remarkable dermal armour, were secured. Subsequently, more than twenty other specimens of these and other species were obtained, so that nearly every part of the osseous structure thus became known, and only portions of the dermal armour were in doubt. A fortunate discovery cleared away most of the doubt in regard to one species, *Stegosaurus stenops*, as the type specimen had the skull, skeleton, and dermal armour together when entombed, and almost in the position they were when the animal died.

With this rich material at hand, an attempt has been made to give a restoration of one of the group, and the type specimen of *Stegosaurus ungulatus* has been selected as the basis. This has been supplemented by a few portions of the skeleton of *Stegosaurus duplex*, apparently a closely allied species from nearly the same locality, while some other parts, especially of the dermal armour, have been placed in accordance with their known position in *Stegosaurus stenops*.

The result is given in Plate XI., which is believed to represent faithfully the main features of this remarkable reptile, as far as the skeleton and principal parts of the dermal armour are concerned. This figure, one thirtieth natural size, is reduced from a larger restoration, one-tenth natural size, made for a lithographic plate to accompany the monograph of the *Stegosauria*, prepared by the writer for the U. S. Geological Survey. When alive, the animal was about twenty feet in length, and nearly or quite twelve feet in height.

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[1] American Journal of Science, III. vol. xiv. p. 513, December, 1877.

[2] *Ibid.* vol. xviii. p. 504, December, 1879. See, also, vol. xix. p. 253, March, 1880; vol. xxi. p. 167, February, 1881; and vol. xxxiv. p. 413, November, 1887.

In this restoration, the animal is represented as walking, and the position is adapted to that motion. The head and neck, the massive fore limbs, and, in fact, the whole skeleton, indicate slow locomotion on all four feet. The longer hind limbs and the powerful tail show, however, that the animal could thus support itself, as on a tripod, and this position must have been easily assumed in consequence of the massive hind quarters.

In the restoration as here presented, the dermal armour is the most striking feature, but the skeleton is almost as remarkable, and its high specialization was evidently acquired gradually as the armour itself was developed. Without the latter, many points in the skeleton would be inexplicable, and there are still a number that need explanation.

The small, elongated skull was covered in front by a horny beak. The teeth are confined to the maxillary and dentary bones, and are not visible in the figure here given. They are quite small, with compressed, fluted crowns, and indicate that the food of this animal was soft, succulent vegetation. The vertebræ are solid, and the articular faces of the centra are bi-concave or nearly flat. The ribs of the trunk are massive, and placed high above the centra, the tubercle alone being supported on the elevated diapophysis. The neural spines, especially those of the sacrum and anterior caudals, have their summits expanded to aid in supporting the massive dermal armour above them. The limb bones are solid, and this is true of every other part of the skeleton. The feet were short and massive, and the terminal phalanges of the functional toes were covered by strong hoofs. There were five well-developed digits in the fore foot, and only three in the hind foot, the first toe being rudimentary, and the fifth entirely wanting.

In life, the animal was protected by a powerful dermal armour, which served both for defence and offence. The throat was covered by a thick skin in which were imbedded a large number of rounded ossicles, as shown in the figure. The gular portion represented was found beneath the skull, so that its position in life may be regarded as definitely settled. The series of vertical plates which extended above the neck, along the back, and over two-thirds of the tail, is a most remarkable feature, which could not have been anticipated, and would hardly have been credited had not the plates themselves been found in position. The four pairs of massive spines characteristic of the present species, which were situated above the lower third of the tail, are apparently the only part of this peculiar armour used for offence. In addition to the portions of armour above mentioned, there was a pair of small plates just behind the skull, which served to protect this part of the neck. There were also, in the present species, four flat spines, which were probably in place below the tail, but as their position is somewhat in doubt, they are not represented in the present restoration.

All these plates and spines, massive and powerful as they now are, were in life protected by a thick, horny covering, which must have greatly increased their size and weight. This covering is clearly indicated by the vascular grooves and impressions which mark the surface of both plates and spines, except their bases, which were evidently implanted in the thick skin.

The peculiar group of extinct reptiles named by the writer the *Stegosauria*, of which a typical example is represented in the present restoration, are now so well known, that a more accurate estimate of their relations to other Dinosaurs can be formed than has hitherto been possible. They are evidently a highly specialized sub-order of the great group which has the typical *Ornithopoda* as its most characteristic members, and all doubtless had a common ancestry. Another highly specialized branch of the same great order is seen in the gigantic *Ceratopsia*, of the Cretaceous, which the writer has recently investigated and made known. The skeleton of the latter group presents many interesting points of resemblance to that of the *Stegosauria*, which can hardly be the result of adaptation alone, but the wide difference in the skull and in some other parts indicates that their affinities are remote. A comparison of the present restoration with that of *Triceratops*, recently published by the writer,[1] will make the contrast between the two forms clearly evident.

All the typical members of the *Stegosauria* are from the Jurassic formation, and the type specimen used in the present restoration was found in Wyoming, in the Atlantosaurus beds of the Upper Jurassic. *Diracodon*, a genus nearly allied to *Stegosaurus*, occurs in the same horizon. *Omosaurus* of Owen, from the Jurassic of England, is the nearest European ally now known, but whether it possessed a crest of dermal plates like that of *Stegosaurus* is doubtful, although caudal spines were evidently present.

II.—The Scandinavian Glacier, and some Inferences derived from it.

By T. F. Jamieson, F.G.S.

It is now fifty years since Charpentier[2] told us that the heaps of Northern boulders which stretch across the plains of Prussia and Saxony mark the ancient limits of the great glacier of Scandinavia, and that the smaller debris met with farther south represents the stuff carried on by the torrents that escaped from the margin of the ice. All this he explained to his incredulous contemporaries, and now after half a century of debate, in which every other conceivable mode of accounting for the phenomena has been tried, it seems to be agreed on all hands that he was right—right in every particular—but, strange to say, it appears to be now generally forgotten that he was the man to whom we owe the first sketch of this explanation.

Agassiz,[3] in 1846, alluding to the previous observations of Charpentier, candidly said, "I was unable to believe in his conclusions when he first imparted them to me, and I made observations in order to combat them, but I have been converted to his mode of view." Charpentier, however, tells us that it was his friend Venetz who was the first to perceive (as he tersely puts it) that "tout le phénomène du terrain erratique trouvait son explication dans l'existence ancienne d'immenses glaciers."

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[1] See Geol. Mag. Dec. III. Vol. VII. 1890, Pl. I. pp. 1-5, and Vol. VIII. 1891, pp. 193-199, Pls. IV. and V., and pp. 241-250, Pl. VII.; and Amer. Journ. of Science, vol. xli. p. 339, April, 1891.

[2] Essai sur les Glaciers, note to p. 319.

[3] Bull. Geol. Soc. France, 2 ser. iii. p. 420, 6 April, 1846.

When the Scandinavian Glacier reached its maximum, it extended over most of Northern Europe and stretched eastward beyond Moscow. To the south-east it went as far as the 50th parallel of lat. on the banks of the Dnieper, and from that its southern border ran westward along the northern base of the Carpathian Mountains and the hills of Central Germany to the mouth of the Rhine. If the starting-point lay in the mountain-chain of Scandinavia, the ice must have travelled to the south-east, a distance of fully 1000 miles. Nitikin[1] tells us that the northern erratics extend over the whole Government of Tschernigow and the east part of that of Kiew, but the unstratified brown Boulder-clay which accompanies them does not go beyond the eastern border of the Tschernigow Government.

General Helmersen[2] says that heaps of northern boulders, generally of small size, but some of them four feet in length, occur as far as Moscow, while further south they rapidly diminish in size to mere pebbles. The large angular blocks mentioned as occurring in the Governments of Kursk and Woronesh are not erratics, but consist of sandstone the same as that of the district in which they are found. The size of the erratics diminishes gradually with the distance from their source. In Finland they are often as big as cottages, and in the Government of St. Petersburg blocks of large dimensions may also be seen. Most of them are of granite and gneiss, such as occur in Finland and Northern Norway.

Judging from the accounts of Torell, De Geer, and other Swedish geologists, the stream of ice that came down the Baltic must have had a length equal to fifteen degrees of latitude, or more, and the whole tenor of the evidence leads me to think that I am not overstating, when I say that the Scandinavian glacier travelled in some directions at least 1000 miles. The reason why it went so far to the south-east no doubt was because there were neither hills nor opposing glaciers to obstruct its march, and the plains of Russia gave ample room for it to spread freely onwards. The Canadian ice seems to have travelled nearly as far in a south-westerly direction, and for similar reasons.

Now what would be the inclination or slope of the surface in a glacier of such dimensions? The nearest thing of the kind that we have any knowledge about is the ice-sheet of Greenland. What the average slope of its surface amounts to has not yet been properly determined, but from all we have hitherto learned it does not seem to be less than half a degree, or 46 feet per mile. In the glaciers of the Swiss Alps the smallest mean inclination is 3° or six times greater.

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[1] S. Nitikin, Die grenze der Gletscher spuren in Russland und dem Ural Gebirge, Peterm. Geog. Mit. 1886; also Geol. Bau der Eisenbahn linie, Gomel Briansk, Russia, 1887.

[2] G. V. Helmersen, Studien über die Wanderblocke und die Diluvial Gebilde Russlands, Mem. de l'Acad. Imp. des Sci. St. Petersburg, 1869.

Nordenskiold's Expedition, in 1883, in lat. 68°, was alleged to have penetrated 160 miles into the interior of Greenland, at which distance an altitude of 6000 feet was said to have been attained. This would give an average rise of 37½ feet per mile over the whole distance; but I suspect these figures cannot be relied upon, because we are told the last 115 miles were done by the Laplanders of the party, whose estimate of the distance seems to have depended on mere conjecture. Nordenskiold himself attained a distance of only 62 miles from the outer edge, at which point he made the altitude to be 4500 feet or 72½ feet per mile. The positions of his camp were determined by solar observations, the other distances by pedometers, while the heights seem to have been fixed by the barometer. How the Lapps estimated the height they reached I have been unable to ascertain.

Dr. Hayes, who believed that he penetrated 70 miles into the interior of Greenland, found that the surface of the ice had a slope at first of about 6°, and then diminished gradually to 2° at the end of the first 30 miles. At 70 miles from the coast he calculated that he had attained an altitude of 5000 feet, which would give about 71 feet per mile, and this is almost the same result as that obtained by Nordenskiold himself. Dr. Nansen states that, in 1886, an American, R. E. Peary, travelled 100 miles from the edge of the iceblink, his highest elevation being 7525 feet. This was further north than Nordenskiold's route in 1883, and gives 75 feet per mile.

Nansen and his party, in 1888, landed on the east coast of Greenland at lat. 61° 30′, and then travelled along the coast northward to Umiavik, lat. 64° 30′. From this, after penetrating ten miles into the interior, they reached a height of 3000 feet. In lat. 64° 50′, at 40 miles from the coast, they were at a height of about 7000 feet on the 27th of August. By the beginning of September they got to a flat extensive plateau, whose height was 8000 or 9000 feet, and which seemed to rise considerably higher to the north. Over this plateau they travelled for more than two weeks, reaching the west coast in lat. 64° 12′ on the 26th September. The breadth of Greenland where Nansen crossed it in lat. 64½° does not seem to exceed 340 English miles, which would make the central point 170 miles from the coast, and taking the altitude at the centre to be 8500 feet, this would give an average slope of just 50 feet per mile. Nansen's results probably afford the best approximation we have yet got, as the fact of his crossing the whole breadth of the land in an ascertained latitude enables us to gauge the extreme distance he penetrated into the interior with some confidence, if our maps are at all correct. Further north the greatest width of Greenland seems to be about 700 miles, which would make the middle point 350 from the coast. A rise of 50 feet per mile on this distance would give 17,500 feet for the altitude of the surface at the centre.

From all we know of the Greenland ice it would seem that the gradient of its surface increases always towards the outer edge, and that for the first hundred miles from the border we would not be justified in assuming an average slope of less than 60 feet per mile, and probably 70 would be nearer the truth. Then for the remainder of the distance suppose we put the slope as low as even 12 feet per mile, we still get the following result for a distance of 1000 miles,

100 miles at 60 feet per mile	6,000 feet.
900 „ 12 „ „	10,800 „
1000 miles.	16,800 feet.

which gives an average of nearly 17 feet per mile over the whole length, and I see no reason for thinking a less slope at all probable. Now the present culminating point of Scandinavia is 8544 feet, and only a very few of the mountain tops exceed 6000 feet; we have therefore a very strong presumption that the former height of that land must have been vastly greater than it is now, and the same conclusion will apply to the centres of glaciation in Canada and Scotland. Supposing that in Scandinavia we place the centre of radiation for the ice not in the Norwegian hills, but in the lower ground to the eastward, still it will not materially affect the result, for although we thereby shorten the length of the glacier, we lower the present altitude of the point from which it had to start. The probability, therefore, seems to be very great that at the commencement of the Glacial period the altitude of Scandinavia was higher—very much higher—than at present, and this conclusion is strongly supported by other considerations of scarcely less weight.

1. In the first place the whole sea-board of Norway is intersected by long deep fjords, which have all the appearance of being the sunken valleys of a submerged mountain-land that had been deeply cut by rivers at a time when the country stood at a far greater height above the sea. Christiania Fjord reaches a depth of 1380 feet, Hardanger 2624, and Sogne Fjord no less than 4080 feet. Their sides are often very precipitous, and Sexe[1] tells us that in the Hardanger Fjord, in fine calm weather, when the water is very transparent, the head turns quite giddy on looking over the side of a boat down these submarine cliffs. Probably few will believe that glaciers could have eroded the hard crystalline rocks of Norway to a depth of thousands of feet beneath the sea-level, or could have cut them into such precipitous forms, for the action of a glacier on its bed has a tendency to produce flowing or bowl-shaped outlines. Moreover, the heaviest current of ice seems to have been that which came down the Baltic, which is a shallow sea, the general depth being only 40 to 60 fathoms. The probability, therefore, seems to be that these fjords of Norway, like the cañon of Colorado, were cut by mountain-streams in pre-Glacial times when the land stood at a much greater height, for how otherwise can we suppose them to have been excavated? The same observation will apply to the sea-lochs which indent the west coast of Scotland and also to the fjord latitudes of America, as Dana long ago pointed out.

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[1] S. A. Sexe, Mœrker, efter en Iistid i omegnen af Hardangerfjorden. Christiania, 1866.

2. Again, Dr. Tyndall reminds us that what we most want in order to produce the glaciers of the Ice-time is improved condensers. Now there is no better condenser that a lofty mountain. Heave it high enough and you will get snow at the Equator, as we see on the Andes, and at Kilima-Njaro in Africa. Here then we have another good argument for a much greater height of the Scandinavian plateau, and the same observation will hold good for other glaciated regions. I therefore think that at the commencement of the Ice-time these countries had a far greater altitude than at present—an opinion which I expressed quite as distinctly thirty years ago.[1] It is difficult, indeed, to see how otherwise a sufficient permanent condensing power could have been sustained in these latitudes; for even in Greenland, at the present day, the line of perpetual snow is 2000 feet above the sea-level, and it is on the high mountain range of the interior that the ice is generated. Dr. Croll,[2] in his paper on the Antarctic ice, asserted that "the Greenland ice-sheet, like the Antarctic, must be thickest at the centre of dispersion and thinnest at the edge." If the ice lay upon a perfectly flat horizontal plane, no doubt it would require to be thickest at the centre, but if the ground supporting it is 10,000 or 15,000 feet higher at the centre than at the edge, as seems not unlikely, then the thickness at the centre of dispersion need not be so very great. If Croll had said that the surface of the ice-sheet must be *highest* at the centre and *lowest* at the edge, it would have been all very well; but the thickness of the ice at the centre of dispersion must depend much upon the altitude of the surface on which the ice rests.

As the ice accumulated upon these lofty regions they appear to have gradually undergone a movement of depression, and the opinion seems to be gaining ground that this depression may have been caused by the weight of ice which was laid upon them.[3] It is at any rate quite clear that after the period of maximum glaciation Scandinavia underwent a partial submergence, during which the great glacier seems to have broken up and disappeared from much of the ground it once covered, and this same order of events seems to have occurred in the other great centres of glaciation in Britain and North America.

Dr. Penck's[4] theory that the submergence was caused by attraction of the ice drawing the sea up on to the land, has not been sustained by an appeal to mathematical investigation; for Woodward in America, Drygalskí, and Hergesell in Germany, and Faye in France, who have in elaborate papers discussed the subject from a mathematical point of view, seem all to agree that the cause in question would be quite insufficient to account for the facts, even on the most liberal estimate of the possible volume of ice. Indeed, it would appear that, owing to the abstraction of water required to form the ice, the surface of the sea would on the whole be lowered, and this effect would surpass the other, however great the thickness of ice, so that the combined effect of the European and North American glaciations, if simultaneous, would be to cause a general sinking of the sea-level during the period of maximum ice. The general result, however, would depend much upon the relative extent of the Arctic and Antarctic glaciers at the time, a subject regarding which we know little or nothing. Penck seems to have been under the impression that the attraction would have caused the sea to rise towards the border of the ice in a comparatively rapid swell, but such would not have been the case. Any rise in the level of the sea induced by such a cause would be nearly parallel to the present surface, and would extend much further horizontally outwards than Penck seems to have contemplated, while its vertical extent would be far less than he supposed.

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[1] Quart. Journ. Geol. Soc. vol. xviii. p. 180–1, Feb. 1862.

[2] Quart. Journ. of Science, Jan. 1879.

[3] G. de Geer, Om Skandinaviens Nivåförändringar under Quartärperioden. Stockholm, 1890. Warren Upham, Review of the Quaternary Era, Amer. Journ. of Science, Jan. 1891.

[4] Schwankungen des Meeresspiegels, Jahrb. der Geog. Ges. zu Munchen, bd. vii. 1882.

If at the commencement of the Glacial period, Scandinavia (or at least a large part of it) stood several thousand feet higher than it does now, then it follows that the subsequent depression must have been very considerable indeed, and the subsidence of such a large area to the extent required would no doubt occasion much squeezing, disturbance, and probably some upheaval in neighbouring regions. I am inclined to think that the ice was gathering on the mountains of Norway at a much earlier period than is generally believed, and that the coming on of the glaciation took place in early Pliocene times, or even sooner. Many of the disturbances that have taken place in the strata near the Straits of Dover and elsewhere may have been occasioned by strains induced by the load of ice, and the bursting out of volcanoes in Germany, Auvergne, and other places may have arisen from pressure on the subterranean lava due to the same cause.

III.—TRANSVERSE VALLEYS IN THE EASTERN CAUCASUS.

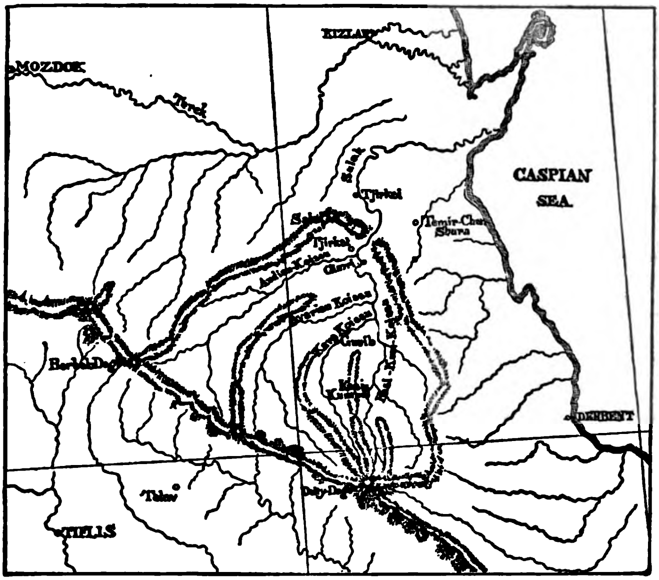
By Professor HJALMAR SJÖGREN,
Professor of Mineralogy and Geology in the University of Upsala, Sweden.

1. *The Sulak gorge below Gimri in Daghestan.*

AMONG the many valleys of Daghestan that are interesting to the geologist there are none more remarkable than the channel by which the river Sulak passes through the chain of Cretaceous and Jurassic mountains which borders Inner Daghestan. Just above the entrance of this defile the four rivers Koissu unite in one stream, which in a series of cataracts tears through a stupendous chasm some fifteen miles in length, cutting the huge ridge almost at right angles to its axis.

The gorge traverses the main chalk ridge in the direction N. 40° E., then changes its line to N.W., which it still follows at the widening of the valley below Tjirkei, and finally comes back to due N. as it passes through the Tertiary hills below Subut. The mean height of the ridge thus cut asunder is some 2000 mètres or more than 6500 feet; in the summit of Salatau, which lies about three miles from the gorge, it reaches nearly 8000 feet; the bed of the river Sulak at its entrance below Gimri is about 1000 feet and at its exit near Tjirkei about 600 feet above the sea. The huge cutting has therefore a vertical depth of from 5000 to 6000 feet, while its breadth is so small that the river leaves no room for a proper road, and scarcely enough for a narrow horse-path, which is itself impassable at certain seasons of the year. The walls of the defile, which mainly consist of a compact dolomitic limestone and show the lines of stratification with unusual distinctness, rise almost perpendicularly into the air and are altogether unscalable. For this reason the valley of the Sulak, which forms a hydrographic link between Inner and Outer Daghestan, is as a means of communication between the two divisions of the province of no significance whatever. The road between Temir Chan Schura and Gimri is carried over the 6000 feet to which the intervening range of mountains here rises instead of being taken through the river gorge. This circumstance is sufficiently indicative of the wildness and inaccessibility of this transverse valley.

Before going farther, I had perhaps better give a short sketch of the orographical structure and hydrography of Daghestan.



Sketch-map of Daghestan, N. Caucasus.

Daghestan lies entirely on the N. slope of the main chain of the Caucasus, though for administrative purposes it is included in Transcaucasia. A reason for this arrangement may be found in the fact that the province is bounded on the N. also by a continuous range of mountains, the peaks of which rise to a height of 8000 or 9000 feet. The main chain of the Caucasus, where it forms the southern boundary of Daghestan, runs in a straight line W. 28° S., while the northern ridge I have just spoken of forms a regular curve, branching off from the other at Barbalo-Dagh and joining it again at Dulty-Dagh. (See Sketch-Map, p. 393.)

The tract of country included between these two ridges is Inner Daghestan. Outer Daghestan is the tract which lies on the outer slope of the more northerly of the two ridges, and which therefore looks towards the Terak Steppe on the N. and the Caspian Sea on the N.E. Inner Daghestan may also be described as the basin of the four rivers Koissu. Surrounded as it is on every side by lofty mountains, this region would be altogether without an outlet for its waters, had not the combined streams of Koissu, which after their junction bear the name of Sulak, found a way to the Caspian Sea through the defile which we are now considering. This narrow gorge is the only channel for the drainage of an area of nearly 5000 square miles.

The physiographical character of these two regions, Inner and Outer Daghestan, is very different. Outer Daghestan consists almost entirely of Tertiary formations, Palæogene (probably Eocene) clay-slates and sandstones, Sarmatian limestones, etc. It is only in the crests of the anticlinal folds that the Cretaceous rocks here and there appear. The strata of this region lie in gentle gradients as a rule, and there are no dips exceeding 45°. The slope towards the Terek Steppe and the Caspian Sea consists of terrace-like plateaux or undulating highlands of a mean height of some 1300 feet, only the branches and outgrowths of the mountain-chain behind reaching a greater elevation.

The character of Inner Daghestan is altogether different. Here, as Abich pointed out years ago, Tertiary formations are entirely wanting. The fundamental rock is exclusively Cretaceous or Jurassic with the exception of certain of the earliest Caucasian schists, the age of which is as yet unknown.

Inner Daghestan again may be divided into two sections, as I have already suggested in my paper "Uebersicht der Geologie Daghestans und des Terek-Gebietes."[1] The lower section consists mainly of limestones and dolomites belonging to the youngest Jurassic and oldest Cretaceous periods, *i.e.* Malm and Neocomian. These formations form extensive and high-lying basin-like plateaux, which often end in precipitous, almost perpendicular, cliffs. It is only in the deep and narrow river-gorges that the schists of the middle Jurassic period come into view. Among these plateaux are that of Keher, lying between the Kara-Koissu and the Kumuch-Koissu, and reaching its highest point in Turtji-Dagh (7950 feet); that of Gunib between the Kara-Koissu and the Avarian Koissu, the highest point of which reaches some 7770 feet; and that of Kunsach between the Avarian and the Andian Koissus, of which the Talokol range (8980 feet) may be looked upon as the southern edge. The southern faces of these huge plateaux, all of which look towards the main Caucasian chain, lie almost in a straight line with a W. 25° N. direction, a line which marks the boundary, so important in physiographical respects, between the upper and lower sections of Inner Daghestan. While the average height of these plateaux is about 6250 feet, the average height of the river beds which traverse them is not more than some 2000 feet. To this great difference of elevation is due the great difference between the climate and products of the deep valleys and those of the high plateaux in this region.

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[1] Jahrbuch der k. k. geolog. Reichsanstalt," vol. 39, p. 417 (1889).

The physiographical nature of the upper section of Inner Daghestan shows a striking contrast to this. Here there are no solid strata of limestone and dolomite, but only loose schists with subordinate beds of sandstone belonging to the Lias formation or the fundamental Caucasian schists. The high-lying plateaux, with their precipitous cliffs, are no longer to be seen; the river-valleys are broader and more practicable; the mountains slope less abruptly, and their sides are modelled more softly by the ramifications of the lines of erosion.

We will now proceed to examine the structure of the chain of mountains which encloses Inner Daghestan to the N. and N.E., and give our special attention to that section through which the Sulak has found a passage.

On the whole the structure of the dividing ridge is very simple, and for the greater part of its length it may be considered as an oblique anticlinal fold or a system of several such folds. This at least is its nature for a length of some 70 miles, from Bozrach in the W. to Suluch-Dagh in the E. Throughout this stretch the ridge, which consists entirely of Cretaceous rocks, forms a boundary as well as a watershed between Inner and Outer Daghestan, and has a mean elevation of nearly 6000 feet. The steeper side of the fold lies throughout inside, *i.e.* it faces S. and S.W., while the strata of the outer slopes show a gentler angle. A marked feature of this particular section of the whole ridge is that the compression of the fold has been more violent than in the adjacent sections, where there has been less disturbance of the stratification.

I may here repeat a passage from another paper of mine which refers to the same region.[1] "I have already shown, when treating of the Cretaceous region of Daghestan, that the boundary between the Outer and Inner divisions of the province is formed by a huge ridge which belongs chiefly to the Senonian, though towards the west the Neocomian also comes in. This watershed throughout a great part of its length consists of an oblique fold. On the outer slope the strata fall gently in angles of from 10° to 20°, on the inner slope steeply, reaching from 60° to 90°."

On the eastern slope of Salatau, immediately above the transverse valley of the Sulak, the mountain is seen to be composed of three of these oblique folds, lying one above the other.

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[1] "Uebersicht der Geologie Daghestans und des Terek-Gebietes." Jahrb. d. k. k. geol. Reichsanst. vol. 39, p. 434 (1889).

From the above short sketch of the main orographical features of Daghestan, we will proceed to trace the course of the four rivers Koissu, a survey of which will help to give the reader a clear notion of the conditions under which the transverse valley we are now considering was formed.

The most westerly, and at the same time the largest, of these four streams, the Andian Koissu, passes first through the deep valleys in the fundamental schists which divide the Katju range of mountains from the main chain, and so far its course is entirely longitudinal. The channel then bends to the N.E., and soon assumes a transversal character, the valley traversing a plicated region of fundamental schists and Lias, and at Konada passing into a tract of folded Jurassic and Cretaceous rocks. In its lower section the channel is alternately longitudinal and transversal; in some places it cuts obliquely through huge folds of Jurassic and Cretaceous strata (Malm to Senonian), while at others it runs parallel with them.

The two middle streams of the four, the Avarian Koissu and the Kara-Koissu, have both eminently transversal courses, as is shown indeed by their general N.N.E. direction, which is at right angles to the prevailing strike-line of the stratification. In their upper and intermediate sections these rivers flow over the fundamental schists and form wide open valleys thickly set with hamlets. But as soon as they enter the Jurassic and Cretaceous formations these valleys become so constricted that they are scarcely habitable. This is especially the case with the Kara-Koissu, the lower portion of which, from Gunib, which is the centre of the government of the district, forms a barren gorge cut in the plateaux of Malm-dolomite and Neocomian limestone. Its only inhabited points are the military stations at the bridges of Gunib and Salti. After this there is no change of direction, as the river continues to cut at right angles through the huge Malm and Neocomian formations, its channel separating the plateaux of Gunib and Salti, which would otherwise form an unbroken whole, and the mountains of Sochtala from those of Koppa.

Much the same state of things is to be seen in the course of the Avarian Koissu, though its valley is not so narrow and impracticable as that of its fellow river. It enters the flat Cretaceous and Jurassic folds at a small angle, and then below Kara-Dagh traverses them perpendicularly.

The most easterly of the four branches, the Kumuch-Koissu, in its upper course from Chosrek to Kasi-Kumuch, the centre of the local government, has a N. 25° W. direction, which corresponds with the general strike of the schists and sandstones over which it passes. On both sides of the valley the strata fall to the E.S.E., the character thus being that of an isoclinal valley. Lower down, near Kumuch, where the river-channel enters the Jurassic and Cretaceous strata, it partly cuts through the huge folds at a sharp angle and partly runs parallel with them.

If we now shortly summarize what I have just said, we shall see that the four rivers Koissu have on the whole a course which traverses the prevailing strike of the stratification, and in their upper valleys flow over soft and unresisting schists of Lias and earlier formations. They then enter a region of folded Jurassic and Cretaceous strata, where they cut through a plateau of synclinal character, the mean height of which is 6250 feet, while the river beds reach no more than some 2000 feet. Still further down, below Gimri, the four streams unite at a height of about 1100 feet, and then, as the Sulak, pass through a range of mountains which reach more than 6500 feet in mean elevation.

For these phenomena I can find no explanation so well supported by the data at hand as the hypothesis that the bed of the Koissu rivers and the Sulak originally lay at so high a level that the water flowed over the great range of mountains without cutting it, and that the transverse valley which now exists was subsequently eroded to its present depth, its erosion keeping pace with the general denudation of the valleys which lay behind. I came to this conclusion when I was travelling in Daghestan in 1888, though I had then given no special attention to the general question of transverse valleys. After my return I was induced to study the subject more closely, and I then discovered that the same or similar hypotheses had been advanced long before.

If we apply this theory to the special case which we are considering, we shall soon see how these rivers in their upper channels, where they flow over soft and easily destructible beds of schist, have managed to hollow out the wide open valleys which there occur, while in the solid and compact limestones and dolomites of the lower part of Inner Daghestan, they have only been able to produce deep narrow cuttings with precipitous walls. General denudation has reduced the level of the upper schist region, till its elevation has become less than that of the limestone and dolomite plateaux and that of the great mountain ridge, all of which once lay below it. The same explanation which serves for the Sulak gorge below Gimri will apply to the narrow defiles at Gunib and Salti in the lower course of the Kara-Koissu, and they may also be regarded as true transverse valleys.

But the whole of the valley system will be still clearer to us if we consider its original history and gradual development.

It was probably at the beginning of the Tertiary period that Inner Daghestan rose above the sea and became dry land. I have already drawn attention to the important fact that there are no Tertiary formations in Inner Daghestan, for which reason we must suppose that this region already lay above the sea, whereas Outer Daghestan consists mainly of formations of this period. On the other hand we find in the lower part of Inner Daghestan among the Jurassic folds remains of Gault and Aptian (Middle and Lower Greensands) which show that the sea of the Cretaceous period covered at least a part of this region. This is also proved by the enormous Senonian deposits which form the dividing ridge between Outer and Inner Daghestan and show a thickness of more than 3000 feet. At the beginning of the Tertiary period, however, it was probably this ridge that formed the limit of the land, and its outer slopes, which look to the N. and N.E., would in that case have been washed by the Tertiary sea.

As soon as Inner Daghestan rose above the sea the work of erosion must have begun. At that time there would have been no river valleys or lines of erosion in the comparatively smooth surface of the country, and the drainage would have followed the general slope to the N. and N.E. To this period we must assign the origin of the valley-system which the Koissu rivers now follow, and it is easy to see how, on the then smooth and featureless surface, the channels could show such independence of the geological structure of the subjacent rocks as we have seen is actually the case.

During the long geological periods that have since elapsed, this region has been exposed to many and great changes. Subterranean forces have raised the whole mountain system of the Caucasus; the forces of denudation have at the same time from prominent points stripped off whole masses of strata and displayed the older formations which lay beneath. Throughout all these changes, however, the Koissu rivers have retained their original course, owing to the fact that the erosion of their channels has kept pace with operations which have threatened to divert them. Just as general denudation has lowered the level of the country which formed their upper basin, so and in a corresponding degree has erosion deepened the narrow defile in which they pass through the barriers of Jurassic and Cretaceous folds, and has produced the present state of things which at first sight strikes us as so abnormal.

This explanation is the same that Penck, in his review of theories to account for transverse valleys, has characterized by the term "Geologische Gefällsthäler,"[1] or valleys which are due to intense denudation in their upper sections. The first to apply the explanation was Gümbel, in the special case of Altmühl in Bavaria. At about the same time and quite independently similar hypotheses were advanced by Jukes and other English geologists to explain similar phenomena in England and Ireland.

These transverse valleys have the important and characteristic feature that their rivers pass from the older formations which lie at their sources on to strata of newer and newer date. The later strata upon which such a river enters in the lower portion of its course were no doubt once present in the region about its source. This region lay, when the river began to run, higher than those tracts through which it now passes further down, but now, owing to excessive denudation of the upper basin, the conditions are just the opposite.

2. *The Gerdiman-tschaj gorge below Lagitsch.*

A precisely similar origin must be assigned to the fine transverse valleys in which the Gerdiman-tschaj, after flowing through the cauldron-like valley of Lagitsch on the southern side of the main

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[1] "Die bildung der Durchbruchthäler," Schriften des Vereines zur Verbreitung naturwissenschaftlicher Kenntnisse in Wien, vol. 28, p. 433 (1888).

Caucasian chain, passes the Lagitsch range, which on the eastern side of the gorge has the name of Nial-Dagh, on the western that of Elgja-Duk. In point of volume the Gerdiman-tschaj river is insignificant compared with the Sulak, but the natural cutting made by it to the south of Lagitsch is little inferior in grandeur to that through which the larger river passes near Gimri.

In order to make clear the topography and geological structure of the Lagitsch valley and the surrounding mountains, I reproduce the following from an earlier paper of mine: "Bericht über einen Ausflug in den südöstlichen Theil des Kaukasus in Oktober und November, 1889."[1]

The Lagitsch valley-system consists of two separate branches, of which the larger and more easterly is the channel of the main river Gerdiman-tschaj, while the smaller, which lies to the west, carries a tributary stream. The two are separated by a mountain ridge running N. and S. and reaching a mean elevation of some 6000 feet. The minor valley forms an almost circular cauldron about six miles across, at the bottom of which lie the villages of Dachar and Wascha. The main valley on the other hand is long and narrow, and may be divided into two sections, of which the upper, running from N.W. to S.E., begins on the slope of Baba-Dagh, while the lower, which runs nearly N. and S., may be said to end with the beginning of the Gerdiman-tschaj defile. Both valleys are separated by high ridges of about 7200 feet from the Pyrsagat valley-system on the E., and from that of Gök-tschaj on the W. On the N. the Lagitsch valleys are bounded by the main range of the Caucasus, which just here rises with excessive abruptness, and reaches its highest point in Baba-Dagh, a peak of 11,940 feet.

The only opening in the mountains enclosing the Lagitsch valleys lies to the S. Here, through the transverse cutting with which we are now concerned, the Gerdiman-tschaj passes a mass of mountain composed of basalts, tuffs, and limestones raised to an almost vertical position. Owing to the comparative impracticability of the gorge, where the encroachments of high-water prevent the construction of a good road, it is only at intervals that a regular communication between the country above and below can be kept up. The most convenient link of connexion is the road which goes to the E. over the pass of Machtokjan-gjadu (7090 feet) to the Pyrsagat valley.

At the entrance of the gorge, a mile or so below the village of Lagitsch, the bed of the Gerdiman-tschaj has an elevation of about 3430 feet. As the ranges of Nial-Dagh and Elgja-Duk, which lie on either side, reach heights of 6900 feet and 7600 feet respectively, it follows that this transverse valley has a vertical depth of more than 3800 feet.

In respect to their geological structure the Lagitsch valleys consist of a huge stratified series of clay-slates, which are to a great extent ferruginous, and thinly laminated limestones, which are impure, compact and often half crystalline. As there are no fossils in these beds,—I have only found in some of the clay-slates doubtful fucoid impressions—the geological position of the whole complex can only be determined indirectly. The petrographic features remind one strongly of the Eocene formations in the Eastern Caucasus, and the superposition upon limestone in the case of Nial-Dagh is analogous to the superposition on Senonian white chalk in the other instance. Moreover, the occurrence of strongly ferruginous clay-slates both to the N. and S. of the eastern Caucasus is especially characteristic of the Eocene period. At the northernmost end of the two valleys, on the side of Baba-Dagh itself, there are thinly laminated limestones raised at considerable angles.

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[1] Mittheilungen d. k. k. geographischen Gesellschaft in Wien, 1890, p. 153.

We will now turn to the structure of the ridge of mountains which the channel of the Gerdiman-tschaj enters as it leaves the Lagitsch valley. This ridge I have myself crossed on the way from Mudschi, a village on the S.E. side, over to Lagitsch, as well as by the route through the Gerdiman-tschaj gorge, in which the stratification is very finely displayed. Regarded as a whole, the Nial-Dagh ridge consists of a colossal fold leaning over towards the S. and is mainly composed of limestones and stratified eruptive tuffs. If we look to the details we see that massive eruptive rocks, with the character of basalt and andesite, also enter into the composition of the ridge. It must still be left an open question whether these eruptives occur as dykes in the stratification or formed beds originally.

As one ascends the slopes of Nial-Dagh from Mudschi, one passes across a series of zones, which in petrographical respects differ from each other distinctly. The series is as follows, beginning from below:—

1. Compact grey thin-bedded limestones, together with light grey crystalline thick-bedded limestones, both of these alternating with soft stratified tuffs, which are often much weathered.
2. Eruptives varying from dark grey to a greyish-green together with the accompanying tuffs, the first forming compact rocks of andesitic and basaltic character, which often split spheroidally, the latter being foliated or thinly bedded.
3. Dark grey shaly tuffs together with conglomerates and pudding-stones; the pebbles of eruptive material or limestone; the matrix calcareous or tuff-like.
4. Light grey crystalline limestones in thick beds, with greyish green shaly and much weathered tuffs.
5. Dark clay-slates, sometimes with green calcareous layers intervening; in some of the conglomerate beds green grains are abundantly distributed and probably come from disintegrated eruptive material.
6. Light grey limestones and greyish green tuffs, as in 4.
7. Thinly-laminated clay-slates, sometimes strongly ferruginous, in thin, reddish brown, sandstone-like beds, and with numerous veins of calc-spar.

The whole of this complex of strata reaches a thickness of some 8250 feet. In 1 the dip was 65°–70° N.N.E., and the strike N. 60° W.; in 4 the dip was 62°–65° N.E., while the strike lay N. 45° E. At the pass (6600 feet) the strata of 7 stood vertically.

I will now shortly state the observations I made during the passage of the Gerdiman-tschaj gorge. The direction is N.E. to S.W., the length about five miles, and to the S.W. the defile increases in width, while the mountains decrease in height.

At the entrance of the gorge, a little S. of Lagitsch, come first the same clay-slates which occupy the greater part of the Lagitsch valley; here the strata dip sharply towards the N. Then come two thick systems of strata, standing almost vertically, and consisting of light half-crystalline limestones, which correspond to the two sections 4 and 6 in the above Nial-Dagh profile, and are separated by a series of clay-slates (section 5 in the preceding profile). One then passes some dark, shaly, and often tuff-like strata, corresponding to section 3, and enters a zone of massive basalts and andesites, answering to section 2 in Nial-Dagh. So far there is complete correspondence with the Nial-Dagh profile, though there the eruptives appear only once, while in the S. portion of the river gorge they form three several divisions of the profile. Between the first and second masses of basalt, reckoned from the N., is a narrow, closely compressed fold of limestone, which has both its limbs dipping isoclinally to the N., and is encased in a mantle of slate. The second and third masses of basalt are separated by thick compound folds of slate, which have a general dip to the N.

If we now summarise the facts that I have adduced as to the geological structure of the various parts of the Gerdiman-tschaj valley, we see that the upper basin of the river on the S. slope of Baba-Dagh consists of hard and compact rocks, but that shortly afterwards the channel passes into the looser-slate of the Lagitsch region, where an open cauldron-like valley has been formed by erosion. On entering the hard limestones and eruptive rocks of the mountain ridge now barring its way, the river has had its channel again constricted to a narrow cleft, as erosion has here been unable to do more than maintain a narrow furrow, at a level which has kept pace with the continual sinking of its upper basin by ordinary denudation.

Our consideration of this valley will thus lead us to the same conclusion that we arrived at in the case of the Sulak. Originally the river bed lay at a much higher level and passed over the ridge of Nial-Dagh instead of cutting through it. Subsequently the wide Lagitsch valley has been hollowed out by the denudation of the loose, soft slates in which it lies. With this denudation and consequent sinking of level the river-erosion which went on below, on the Nial-Dagh section, has been able to keep pace, and the stream, working, so to say, after the manner of a saw, has cut a deep groove through the mountain ridge of hard and compact rocks.

It is well worthy of notice that the river has chosen a point in the ridge where for the sake of a channel it had to cut through three huge columns of basalt and where the work of erosion must have been considerably more difficult than farther east. This fact is in full agreement with the circumstance that transverse valleys of this kind, as is shown by observations elsewhere, often cut their way through some mass or column of hard rock which could easily have been circumvented. This should be a proof that such channels have originally passed at a far higher level, when the obstacle in question was absent, and that they have since contrived in spite of it to pursue the course they had once adopted.

The Gerdiman-tschaj shows us well that the rule of permanence of channel holds good, not only in the case of large and deep rivers, but also in the case of so comparatively insignificant a stream as this, which at certain seasons of the year runs almost dry and has so trifling a volume of water that it disappears completely in the Kura Steppe without reaching either river or lake of any kind. And yet this small volume of water has been able to execute so grand a piece of erosive work.

IV.—ON THE SANDS AND GRAVELS INTERCALATED IN THE BOULDER-CLAY.

By G. W. BULMAN, M.A., B.Sc., Corbridge-on-Tyne.

(*Concluded from the August Number*, p. 348.)

On the Italian side of the Alps a similar set of lignite beds occurs as on the Swiss side. But these Italian lignites, although occurring *beneath*, are not *underlaid* by glacial deposits.

Evidently, then, they afford even less evidence of an interglacial period than those on the Swiss side; and this Prof. Geikie himself seems to confess; for he writes of them:

"They are clearly of older date than any recognizable morainic or diluvial deposits in Northern Italy; and if it were simply a question of local geology, one could have no good reason for doubting their pre-glacial age."[1]

And yet, taking them along with the Swiss beds, he finds in them similar witness to an interglacial period.

With regard to the "marine sands" with which the lignites seem to be contemporaneous, Prof. Geikie considers the evidence of their fossil shells insufficient to establish their pre-glacial age.

The number of extinct species in the sands is said to be from 15 to 20 per cent.; and if we compare this with the 18 per cent. extinct species of the Norwich Crag, the inference seems obvious that the beds are *pre-glacial.*

Prof. Geikie points out, however, that such comparisons are only conclusive when confined to the same geographical area; and when we substitute the Italian Pliocene for the English, a very different conclusion is suggested. For in the lowest beds of the former the per-centage of extinct shells is 83, and in the Upper 68. If, then, these Italian Pliocene are rightly classed, the lignites must be at any rate Post-Pliocene. But even then, it is still possible they may have been formed before the ice reached the district where they occur. A local geologist, however, the Italian Prof. Gastaldi, does not consider the Italian lignites to be interglacial. At the same time he believes them to be of the same age as the Swiss beds. But if the Swiss lignites lie *upon* glacial beds, and the Italian *below* glacial beds, and if they are of the *same* age, it *follows* that the lignites *must* be interglacial.

The argument seems to hinge on the question whether the organic remains indicate a similar age for the lignites on the two sides of the Alps. Mammalian remains are found in Swiss lignites, and are of distinctly recent aspect: they are,—

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[1] Great Ice Age, p. 527.

(1) Asiatic Elephant (*Elephas Indicus*) (*E. antiquus*?).
Urus (*Bos primigenius*).
(2) Stag (*Cervus elaphus*).
(3) Cave Bear (*Ursus spelæus*).
Rhinoceros sp. (*R. Merkii*?).

(1) It is somewhat difficult to decide how old a deposit may be which contains this living species, as it is so seldom found fossil.

Writing in 1868, Dr. Hugh Falconer states that, "There is no good evidence of the existing Indian Elephant having as yet anywhere in India or in Europe been met with in the fossil state."[1]

And according to Woodward and Sherborn (British Fossil Vertebrata) it has not been found fossil in Britain.

(2) This species is found in the ossiferous caves of Wales and Gibraltar, in the Norfolk Forest-bed, in Pleistócene, Prehistoric, and Historic deposits. This leaves a wide margin for the age of the beds in which it occurs.

(3) This occurs in the Forest-bed, in the Pleistocene, and in the caves. Again no evidence as to age.

On the whole such an assemblage might have occurred at any period from late Pliocene to Postglacial times. And yet the general aspect of such a fauna suggests a *later* period than one in which 15 or 20 per cent. of the Mollusca are extinct.

And finally, even if the lignites are interglacial as to position, this does not, as we have seen, necessarily indicate a warm interglacial climate.

In America, again, Professor Geikie finds evidence of warm interglacial conditions:

"Another interesting feature in the American glacial deposits is the occurrence of intercalated fossiliferous beds."[2]

According to Prof. Newberry the succession of changes indicated are as follows:

1st. A period of a great continental glacier or ice-sheet.

2nd. The retreat of the ice, and the appearance of a vast freshwater lake (covering a large part of Ohio), in which were deposited the Erie clays, etc.

3rd. The silting-up of the lake, and the advent of a luxuriant forest-growth.

4th. The submergence of the land and the deposition from floating ice of blocks and boulders.

And the resulting succession of beds was as follows in descending order:

1. Iceberg drift.
2. Forest bed.
3. Erie clays.
4. Glacial drift.

The "Iceberg Drift" above the Forest Bed, however, does not necessarily imply a return of Arctic conditions after a mild interval; it may simply represent a phase in the gradual retreat of the ice when its southern extent was still greater than it is to-day.

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[1] Pal. Mems. vol. ii. p. 157.

[2] Great Ice Age, p. 416.

It may have retreated far enough to allow of the deposition of the Erie clay in Ohio (between lat. 38° and 42°) near its extreme southern limit, the silting up of the lake, and the growth of forest upon it.

If the land then sank, it need not be supposed that the southern fringe of the retreating ice was too far off to allow it to send icebergs floating over the submerged land, and depositing the "Ice-berg Drift" on the "Forest-bed."

The phenomena of the American "inter-glacial beds," in fact, seem to mark the retreat—perhaps intermittent and with prolonged pauses—of the ice, rather than the occurrence of a warm climate between two periods of cold.

And this is the opinion to which Dr. Wright inclines after prolonged and careful study of the glacial deposits and actual glaciers of North America, although it is in opposition to that expressed by other American geologists. In his "Ice Age in North America," he expresses himself thus:

"A thorough study of the condition and distribution of the buried forest beds bears strongly, as I cannot but think, against the complete separation of glacial epochs in North America. In addition to the facts about to be enumerated, it is a significant circumstance that the buried vegetable deposits under consideration do not mark a warm climate, but a climate much colder than the present—such a vegetation, in fact, as would naturally flourish near the ice margin. The buried forests of Southern Ohio have a striking resemblance to those we described in Glacier Bay, Alaska. Peat and hardy coniferous trees are predominant."[1]

And again,

"Usually, as has been remarked, these buried deposits of peat and wood have been assumed to imply the existence of two distinct glacial periods. But, from what has been said above, it would appear that the facts point rather to shorter periods of advance and recession of the ice-front, analogous to those which are now in progress in the Alpine glaciers, as heretofore noted."[2]

At the same time Dr. Wright admits difficulties in the case of some of the more northern deposits:

"It must be confessed, however, that some of the facts concerning vegetal deposits still further north, especially in the valley of Lake Agassiz, are more difficult to explain upon the theory of a single glacial epoch."[3]

And finally summing up the matter he writes,

"Such are, in brief, the considerations which seem to make it proper to hesitate before recognizing the theory of two distinct glacial epochs in America as an established doctrine to be taught. Most of the facts adduced to support the theory of distinct epochs are capable of explanation on the theory of but one epoch with the natural oscillations accompanying the retreat of so vast an ice-front."[4]

The intercalated beds on the Norfolk coast are instructive. They are described by Mr. Clement Reid[1] as "well-laminated ripple-marked clays and marls with seams of fine false-bedded sand, deposited on the hummocky surface of the First Till," and are in turn overlaid by the Second Till. They have not yielded any fossils except shell fragments derived from the Boulder Clay, and Mr. Reid is led to the following conclusions as to their origin:

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[1] *Ib.* p. 482. [2] *Ib.* p. 490. [3] *Ib.* p. 495. [4] *Ib.* p. 500.

"The absence of all signs of life appears to point to a freshwater origin for these beds, and for the similar unfossiliferous laminated clays which are so common in glacial deposits in other parts of England. Modern glacial lakes show a similar barren character" (p. 88).

Finally, Mr. Reid does *not* consider that they afford evidence of an inter-glacial warm climate:

"After the deposition of the First Till, the ice appears to have retreated, perhaps only for a few miles, leaving the Boulder Clay with a curious hummocky surface, over which was deposited ripple-marked clay and marl in thin beds. This deposit seems to be glacial mud, such as would flow from beneath the ice, and be spread over the surface lately abandoned. Such an evenly-bedded loam cannot be taken as sufficient evidence of an inter-glacial warm climate, though it is traceable nearly continuously for at least four miles; for at the present day glaciers of the Alps and the ice of Greenland advance and retreat short distances without any very marked cause."[2]

Nor do the sands which come between the second Till and the Boulder clay or Stony loam afford any stronger evidence. They are described as "fine false-bedded loamy sands, always chalky and carboniferous, and of a peculiar pale tint, easily recognizable;" and they rest on the eroded surface of the Till. Like the beds between the first and second Tills they have yielded no fossils.

And this so-called Boulder-clay is a deposit of rather a curious character. In general composition according to Mr. Reid it is much like the underlying till, but it contains *bedded masses of sand* of which the bedding is often vertical. It perhaps marks an advance of the ice less pronounced than that which produced the second Till, and which permitted more freely the action of streams.

The inconclusive nature of the evidence derived from the intercalated sands and gravels is further illustrated by a study of those of South Lancashire as described by Mr. A. Strahan (Q.J.G.S. vol. 42, p. 362).

According to Mr. Strahan these sands and gravels "usually underlie Boulder-clay." Yet there is no evidence of glacial action beneath them: "Lastly, it is almost invariably under Boulder-clay that the rock has been found to be striated. Though the sands and gravels are included among the glacial deposits, the Boulder-clays alone show direct evidence of the action of ice." On the Welsh coast, on the other hand, Boulder-clay is described lying beneath marine drift:—"The occurrence of a tough blue basement clay packed with stones, most of which are scratched, underneath the undoubted marine drift of the Welsh coast, has been previously noted."

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[1] Geology of the Country around Cromer, Mem. Geol. Surv.

[2] Ditto, p. 91.

The view that these sands and gravels are interglacial rests on the assumption, that the beds thus lying above the Boulder-clay in one place are of the same age as those lying beneath it in another.

The mammalian and other remains found in the intercalated beds are taken by Professor Geikie as evidence of the mild climate he supposes to have prevailed. Yet similar remains are noted as occurring in the Till itself:

"In the mass of the Till itself fossils sometimes, but very rarely, occur. Tusks of the Mammoth, Reindeer antlers, and fragments of wood have from time to time been discovered in this position."[1]

And there are so many ways in which such remains as are found in the intercalated beds might come to be imbedded in them that a mild interglacial climate should not be assumed without very strong evidence.

It seems to be generally inferred, that the glacial conditions drove such Mammalia, and other temperate forms, out of the country, and that a mild interval, and a union of England with the continent, was required to allow of their return.

But is it not possible they may have lingered in the southern unglaciated districts, migrating northwards during the summer, and occasionally leaving their remains where glacial deposits were being laid down? And a succession of warm summers might induce them to travel to higher latitudes than usual. And it is worthy of note that these mammalian remains are found in the *lower districts*, where there would be less ice and milder conditions, and where the ice was likely to melt most completely during the summer. Prof. Geikie accounts for their absence on the higher grounds by the greater intensity of the glaciation which he thinks removed them; but the alternative explanation that they never existed there is worthy of consideration. And a hint of how mammalian remains may come to be imbedded in deposits far beyond the usual habitat of the species is afforded by Dr. Meyer, in his account of his recent exploration of the glaciers of Kilimanjaro in Eastern Equatorial Africa:

"We were about half way through this terrific bit of work," he writes, "when we came upon what was perhaps as wonderful a discovery as any we made in Kilimanjaro. It almost savours of the fabulous, but here in this stern frost-bound region, at the very summit of a mountain 20,000 feet high, we lighted on the dead body of an Antelope—one of the small species we had noticed on the pasture-lands below. How the animal came there it is impossible to say. In all probability it had made its way upward by the same path as ourselves, at a time when the ice was covered by its winter coating of snow, and overtaken in these lofty solitudes by the fury of a mountain-storm, had paid with its life the penalty of its adventurous curiosity."[2]

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[1] Great Ice Age, p. 164.

[2] Across East African Glaciers, by Dr. Hans Meyer, pp. 183–4.

And Colonel Tanner, in his description of a Himalayan glacier, shows how vegetation and ice-action may overlap. The following passage occurs in a paper read before the Geographical Society (see *Nature*, April 30th, 1891, p. 622):—

"Speaking of the Himalayan glaciers, Colonel Tanner stated that the most extensive and picturesque he has ever seen are in the Sat valley, which drains the southern face of the Rakaposhi mountain in Gilgit. Three great glaciers come down into this valley, and dispute with the hardy mountaineers for the possession of the scanty area of the soil. Here may be seen forests, fields, orchards, and inhabited houses all scattered about near the ice heaps. The only passable route to the upper villages in this valley crosses the nose of the greatest of the three glaciers, and threads its way over its frozen surface. This glacier is cut up into fantastic needles of pure green ice, some of which bear on their summits immense boulders. About half a mile from its lower end or nose, Colonel Tanner found an island bearing trees and bushes, and at one place above this a very considerable tarn of deep blue-green water. The glacier had two moraines parallel to it and with each other, and both bearing pine trees."

Dr. Wright also describes the close proximity of glaciers and an abundant flora and fauna in North America at the present day:

"The mountains on each side of Muir Inlet rise immediately from the water from three thousand to five thousand feet. These we often ascended, and were thus permitted repeatedly to behold one of the most marvellous views anywhere to be found in the world. At that season the level places around our feet upon these summits were carpeted with soft green grass, interspersed with large areas of flowers in full bloom. Here were extensive, gorgeously-coloured flower-beds, where bluebells, daisies, buttercups, violets, the yellow arnica-flower, and the purple epilobium, were striving for mastery or for recognition. On the northern slopes of slight elevations great masses of snow were preserved in the very midst of these brilliant flower-gardens, and from their melting, clear little pools of water were on every hand inviting us to drink. The tracks of the mountain goat, the mountain lion, and of various smaller animals, and the songs of birds witnessed to the abundance of animal life. . . . In such a setting of grandeur and beauty we gazed upon the full face of the great glacier itself lying at our feet. Below us its diminishing outlet disappeared in the waters of the bay. Distance made the rough places plain, and lent enchantment to the view. Down from the mountains in every direction from the north came the frozen torrents;—

Glaciers to the right of us,
Glaciers to the left of us,
Glaciers in front of us,
Volleyed and thundered—

pouring into a vast amphitheatre, and then uniting their volumes, preparatory to their exit through the entrance into Muir Inlet."[1]

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[1] Ditto, pp. 37–39.

The same writer further describes some of the islands in Glacier Bay—at the head of which is Muir Inlet—as covered with vegetation:—"Near the mouth of Glacier Bay is a cluster of low islands named after Commander Beardslee, of the United States Navy. There are twenty-five or thirty of these, and they are composed of loose material—evidently glacial *débris*—and are in striking contrast with most of the islands and shores in south-eastern Alaska. These, also, like all the other land to the south, are covered with evergreen forests, though the trees are of moderate size."

It is obvious that a very slight advance of the ice—such as are known to be of common occurrence—might cover this vegetation with glacial deposits and present all the phenomena of "interglacial beds."

Another indication of the possible close association of a Mammalian fauna, and the action of ice is furnished by the phenomena of the region of Hundes in India.

No glaciers descend there below 14,000, and very few below 16,000 or 17,000; and it has been shown by Mr. Lydekker that Wild Horses (*Equus hemionus*) and Yaks (*Bos grunniens*) live there at elevations of 15,000 feet. That remains of these could very easily be imbedded in glacial deposits is obvious.[1]

And that vegetation may occur on the *higher* ground, while intervening valleys are filled with ice, is indicated by Lydekker's account of the glaciers of Baltistan.

Of the Tápsa glacier he writes:

"Cypress trees extend to a height of 1000 or 1500 feet above the level of the glacier."[2]

A further illustration of the overlapping of an even temperate vegetation with the ice is given in Rendu's "Glaciers of Savoy."

He speaks of the ice advancing between banks covered with flowers, and adds, "I stopped near a field of rye which was by the side of the Glacier des Bossons. An ear, almost ripe, and swayed by the wind, each instant touched the ice, and drew back as if frightened by this strange guest come from a climate which has no power save for death."[3]

It is obvious, in fact, that while the higher part of a glaciated region may be removed from all animal or vegetable life, the lower or melting portion must in some way invade the zone of living creatures, and thus tend to mingle their remains with the tokens of ice action.

But do the facts of the case admit the supposition that any considerable portion of our fauna and flora were actually able to exist in the southern unglaciated portion of Britain during the period of intense cold?

On the hypothesis that the ice-sheet extended as far south as the latitude of London, there seems but a small area left—and that in close proximity to a great ice-sheet—for its conservation. But in connexion with this point some remarks of Sir Charles Lyell in relation to existing conditions in Greenland should be borne in mind.

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[1] See GEOL. MAG. May, 1891, pp. 209–210.
[2] Records Geol. Surv. India, vol. xiv. p. 44.
[3] Translation, p. 68, Edited by Prof. George Forbes.

"The perpetual snow," he writes, "usually begins at the height of 2000 feet, below which level the land is for the most part free from snow between June and August, and supports a vegetation of several hundred species of flowering plants, which ripen their seeds before winter. There are even some places where phenogamous plants have been found at an elevation of 4500 feet, a fact which, when we reflect on the immediate vicinity of so large and lofty a region of continental ice in the same latitude, well deserves the attention of the geologist, who should also bear in mind that while the Danes are settled to the west in the 'outskirts,' there exists due east of the most southern portion of this ice-covered continent, at the distance of about 1200 miles, the home of the Laplanders with their Reindeer, Bears, Wolves, Seals, Walruses, and Cetacea. If, therefore, there are geological grounds for suspecting that Scandanavia or Scotland or Wales was ever in the same glacial condition as Greenland now is, we must not imagine that the contemporaneous fauna and flora were everywhere poor and stunted, or that they may not, especially at the distance of a few hundred miles in a *southward* direction, have been very luxuriant."[1]

Nor must we lose sight of the *possibility* that the land extended further south in glacial times than now; or was even perhaps joined to the continent. For it is still a moot point whether glacial Britain was a cluster of low, ice-covered islands, or a highly elevated glaciated region surrounded and united to continental Europe by a great plain inhabited by an abundant flora and fauna.

We must further remember that the supposition that the ice-sheet extended thus far south is founded on the hypothesis that the Till was formed *beneath* the ice-sheet, and this view of its formation is by no means certain or universally received.

Prof. Boyd Dawkins, for example, points out that the evidence from "causes now in operation" is against this view. For, as he remarks, no similar deposit is found where glaciers or ice-sheets have retreated; whereas in Davis Strait an analogous formation is being laid down by the water from the melting ice entering the sea.

If this view of the formation of the Boulder-clay be adopted, the ice-sheet may be supposed to have terminated much further to the north, and the difficulty of supposing a part of the pre-glacial fauna and flora to have found an asylum much lessened.

The peculiar flora of the south-west of Ireland seems to me to afford a hint that a portion, at least, of our plants and animals were not entirely driven out of the country. For there are difficulties in the way of the supposition that this peculiar flora—not now found further north than Spain and Portugal—migrated there *after* the glacial epoch; and Prof. Forbes, in his essay on the fauna and flora of the British Isles, inclines to the view that the migration took place *before*.

If this is true, these plants must have survived the Glacial epoch; and if these, why not many others of our plants and animals?

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[1] Antiquity of Man, p. 278.

A similar hint is offered by the fact that the glacial drift of the west of England, and of parts of Ireland, contains mollusca of a more southern aspect than that of the east side of the former. For it allows us to suppose a milder climate existing on the west all through the period of cold, and thus affording a retreat for forms which might otherwise have perished.

Thus, although the question of the probability of mammalian and other remains in the glacial drift of Britain without the intervention of warm intervals, cannot be definitely settled until the preliminary one of the extent of the land of the Glacial period is disposed of, enough has been brought forward to show how easily it might happen under certain conditions.

Finally, it may be affirmed that the evidence that the intercalated sands and gravels were formed during a mild interglacial period is in *no single case* conclusive; that while they are *not* the sort of deposits to be, *a priori*, expected as the result of a mild interval, they *are* just such as would naturally result from the action of subglacial streams, the oscillations in the extent of the ice causing the overlapping of glacial and aqueous deposits, and the work of the ice itself; and that a gradually, but intermittently, advancing ice-sheet, or glacier, could not avoid overwhelming and burying in its own debris masses of vegetation, while the latter, closely following the retreating ice, and growing on its accumulations, could not fail now and again to be buried beneath the deposits of some temporary advance of the same.

And since, looking to the present, the work actually done beneath an ice-sheet or glacier—especially in those parts remote from its lower margin—is still shrouded in mystery, it seems rash to assign every bed which does not conform to our usual idea of the work of the ice to an interglacial epoch.

V.—RECENT GEOLOGICAL INVESTIGATIONS IN THE SALT RANGE.

By A. B. WYNNE, F.G.S.

THE Geological Survey of India Records, vol. xxiv. part 1, 1890, only came to hand to-day, enabling me to see Mr. Middlemiss's late paper on the Salt Range.

It appears to be one of the many charms and mysteries of Salt Range geology that it affords fresh discoveries to each successive explorer; hence, possibly, something yet remains to reward the next pilgrim who may have the chance to criticize Mr. Middlemiss's conclusions,—let us hope instructively.

The paper at present referred to possesses a great deal of interest, and has much importance with regard to structural geology. I trust it may receive worthy notice under light more modern than that in which my Salt Range work was carried out more than twenty years ago, without the advantage or disadvantage of a tendency to form foregone opinions about the views of others before I reached the ground. Perhaps I may also remind readers that when I was thus engaged, the doctrines of inversion, earth-thrusts of several miles, and shearing, so largely affecting Mr. Middlemiss's views, and which arm his criticisms, were in their early infancy or still unborn, and had not been developed by the exhaustive researches in complicated districts of the Scottish geologists, whilst complex superficial displacements from landslip abounded in degree and magnitude sufficient to render conclusions as to inversions, etc., such as the paper advances, very doubtful.

One conclusion (not the author's alone), namely, that the Boulder beds form a single continuous horizon, seems incontrovertible upon the accepted evidence advanced for unconformity. This relation is easier to understand when it is assumed that the Salt Marl is an accidental associate, and not integral as an original basal part of the series. Regarded as of the latter nature, in intimate connexion with the lowest succeeding members, whether boulder conglomerates or sandstone, it was of course impossible to hold such boulder rocks to be contemporaneous with others, at a higher stratigraphical level, in an apparently perfectly conformable sequence. The interpretation depended upon the existence of either conformity or discordance within beds lying in a general way more or less horizontally, and the question formed one of those problems more likely to be solved by the application of broad considerations than of local details.

The paper itself suggests an illustration of this where reference is made to derived pebbles as proofs of discordance; for it is an uncontested fact that sandstone beds *in the Eocene group* trans-Indus enclose rounded pebbles of fossiliferous Nummulitic limestone, and are overlaid by conformable beds of similarly fossiliferous Eocene limestone with little or no disturbance (Mem. G. S. I. vol. xi. p. 35, *et. s.*). In other cases formations containing rolled fragments of their own rocks have also been recorded. The inference from these cases is quite as strongly in favour of conformity as of discordance: in fact, as strict evidence of the latter, the occurrence of these pebbles has little or no weight. If this be true of trans-Indus Nummulitic pebbles, why should it be otherwise as to dolomite pebbles from the Salt Marl in an overlying conglomerate? or as to Eocene limestone pebbles in the next Tertiary layers above? In each case the separation as to time is reduced, and the likelihood of a break diminished, leaving to wider general considerations rather than to dogmatic rules the position of the safest guides. At the same time the contention of Mr. Middlemiss may be correct, but the case affords an instance in which each observer is at liberty to form, or even to alter, his own conclusions according to his lights.

The most important part of the paper is the author's suggestion that the sub-Cambrian Salt Marl has no ordinary stratigraphic relations with the rest of the series, but is of plutonic, igneous or deep-seated origin, introduced in Tertiary times, accompanied by lateral and vertical disturbance, thrusting, and shearing. The idea of an igneous or deep-seated origin for rock-salt formations is not new; it was considered and discussed so far as possible before my Salt Range Memoir was written, but there did not then seem sufficient evidence to found a case adverse to the generally received theory of production of saline deposits. I gather that, notwithstanding what is now advanced, the case is still incomplete, yet I trust Mr. Middlemiss will follow up the subject to conclusions that cannot be called hypothetical, and may effectively reconcile several obscurities on both sides of the Indus.

When I was at the Salt Range, the facts of internal lateral thrust displacements not having been demonstrated, it was plain the series must have been laid down upon something, and the marl occupied the place of the visible floor to the rest. Supposing the part above to have been unconformably deposited, what conditions would have preserved a soft saline marly mass to have received later accumulations? But if it was found immediately succeeded by earthy layers passing up into sandstones, the main conditions for tranquil sequence would seem to have been present as I saw the sections. I have not seen the brecciated junctions of the Purple sandstone with the underlying marl as described in the paper, nor do I quite grasp how such a condition—not merely superficial, but the result of deep friction—might be established between substances like soft 'scum' and hard sandstone. This, of course, is said with reserve, and subject to correction by students of earth-movements, thrusting, and so forth, which I have not had the advantage of working out in natural exposures.

While greatly interested in Mr. Middlemiss's frank, able, and lucid contribution to the literature of the Salt Range, I am yet fain to hope that—aside from subsequent revelations in structural geology—other readers of my memoir will find most of its conclusions reasonable at the time it was written. Our knowledge is happily progressive, and considering the extent of the region itself, with the circumstances governing its exploration, I can scarcely feel vain regret that something did, or may still, remain to be discovered. On the contrary, few will learn with greater satisfaction of solid additions or improvements to what has been already ascertained, notwithstanding that the results, such as they were, which attended my labours for rather more than two working seasons, cost me a good deal of thought and exertion, with serious loss of health, and consequently of my employment—considerations, however, already amply recognized as having nothing whatever to do with the geology of the Salt Range or other regions. Nevertheless, the retrospective pleasure of appreciating the observations of later investigators made upon the spot, must still remain possible to an old field-geologist like myself.

KINGSTOWN, 23*rd July*, 1891.

VI.—REPORT ON SOME ROCK-SPECIMENS FROM THE KIMBERLEY DIAMOND-MINES.

By Prof. T. G. BONNEY, D.Sc., LL.D., F.R.S., F.G.S.,
and Miss C. A. RAISIN, B.Sc.

[From a collection of stones obtained from the refuse-heaps of the Kimberley Mines by Mr. Louis Atkinson, a selection was made by Prof. T. Rupert Jones and, by kind permission of Prof. Bonney, was submitted to him for examination, in packets marked I.—VIII. and X. Specimen No. IX. was sent many years ago, as a trap-rock with garnets from the Vaal River, by Mr. Robert Crofts Jones.—T. R. J.]

For the most part the specimens were too small to permit of slices being made; the results therefore were in such cases obtained by examining the powder got by crushing the fragments.

I. *a.* The green mineral is Enstatite, and is associated with a colourless transparent mineral, appearing cracked and fractured, which seems to be probably Topaz.

β. A clear bright-green crystal of Enstatite.

γ. The green mineral is a Pyroxene, and is intercrystallized with red Garnets.

δ. A slide was prepared of this specimen, which showed that it consisted of Garnets enclosed in a green Pyroxene, probably Omphacite, with small rifts or tubuli traversing the crystal transverse to the prism-zone. A colourless transparent mineral is associated with the Pyroxene; it has straight, or nearly straight, extinction, and might be Zoisite or possibly Kyanite.

II. *a.* A transparent, pale, resin-coloured specimen of Topaz.

β. A bright green Pyroxene, with a yellowish or greenish-grey mineral, which has one good cleavage and straight extinction, and may be Zoisite. Very dull purplish Garnets are included, and flakes of brown Mica.

γ. A Pyroxene of rather foliated habit, having a clear, deep, rich green colour and a sub-metallic lustre, apparently like the Omphacite described by von Drasche. To this is attached a white fibrous mineral evidently a carbonate, probably Calcite.

δ. A pale sea-green mineral with silky or pearly lustre, which shows well-marked cleavages, breaks into rhomboidal forms, and appears to be a variety of Diallage.

III. Many specimens of Iron-pyrites; also others of a rock composed of Pyroxene, Garnet, and (?) Zoisite.

IV. *a.* Matrix seems to consist of minutely granular Serpentine and Olivine with some brown Mica—a ground-mass apparently similar to that in the slide cut from specimen VI. Green crystals of Augite are enclosed.

β. Garnets enclosed in a clear greenish mineral, very pale in tint when seen in thin flakes under the microscope, and somewhat foliated; it is probably a pyroxene of the nature of Omphacite.

γ. Three specimens of *Garnet-pyroxene-mica-rock*, as described, II. *β.*

δ. Three specimens of *Garnet-pyroxene-*(?)*zoisite-rock,* as previously described, III.

V. Specimens of Ilmenite (called "carbon" by the miners).

VI. A slide prepared from this rock shows a ground-mass, the constituents of which are difficult to distinguish; it appears to be an irregular mixture of brown Mica, brownish-green Serpentine, and a dirty-looking mineral, which is seen with polarized light as an aggregate of fine granules, and in parts seems to be associated with the serpentine in a sub-ophitic way. Within the ground-mass are well-formed crystals of green Augite, also red Garnet and brown Mica. Some Olivine is in good preservation, and Serpentine occurs, dark- to light-green, the result of the alteration of a ferro-magnesian silicate, most probably an Olivine rather rich in iron. The rock thus would seem to be a *Granatiferous Picrite.*

VII. These irregularly cylindrical bodies consist apparently of small fragments of the minerals of the rocks, Garnet, Pyroxene, etc., and also of well-rounded Quartz grains, all the constituents being cemented together, apparently by Calcite. The structures may very possibly be concretionary and have formed within a sandy rock.

VIII. From examination of the powder obtained by crushing a fragment, this specimen appears to be Pyroxenic,—a pale-greenish minutely crystalline Augite.

IX. This rock consists of red Garnets, with rather perfect crystal faces, imbedded in a brown ground-mass. A slide has been prepared which shows that the matrix consists of an ill-defined crystalline mass, including either incipient or partially-decomposed forms of a mineral which has an appearance suggesting crystal outlines of a Felspar-like character. Some Quartz may also be present. A brown Mica occurs, rather iron-stained, and somewhat confusedly crystallized. There are also crystals, which are short stout prisms, rather rounded, terminating in basal and dome planes, transparent and colourless, highly refractive, and with straight extinction; these may possibly be Topaz. The somewhat decomposed and iron-stained condition of the rock makes it difficult to speak with precision, but on the whole the probability is that it is a somewhat altered fine-grained *Granatiferous Mica-Diorite.*

X. Quartz pebbles.

Note by Prof. T. Rupert Jones, F.R.S.

The following specimens were previously supplied by Mr. L. Atkinson, and returned to Kimberley labelled for the use of the miners and others.

1. Slag of "Blue Ground" (local matrix of the diamond) artificially burnt.

2. Tufaceous concretions, roughly cylindrical and branched, formed locally near the surface, from the decomposition of the felspar of igneous rocks yielding carbonate of lime, and the calciferous water percolating sandy strata.

3. Pebbles and fragments of chalcedony from the agates of amygdaloids, either local or drifted from the upper country. 4. Quartz crystal, probably from an agate. 5. Calcite, probably from the local tufa or from an agate. 6–10. Iron-pyrites in irregular, knobbly, concretionary forms; Hematite; Ilmenite; Garnet; Epidote; probably from the "Blue Ground."

11. Shale veined with calcic carbonate. From the "Kimberley Shale" of the "Lower Karoo" formation, traversed by the diamond-stuff. 12. Porcellanite; possibly burnt shale. 13. Silicified wood; coniferous, from the "Upper Karoo" formation. 14. Soft ferru-

ginous grit-stone; probably from the Karoo Beds. 15. Sandstone; from the Karoo Beds. Nos. 13 to 15 have been drifted from the Stormberg and neighbourhood higher up the country. 16. Pebble of brown quartzite; possibly from the Karoo Beds.

17. Mundic in slate. 18. Siliceous schist, or brown banded lydite. 19. Jasper. 20. Vein-quartz. Nos. 17—20 have been derived from the old rocks; probably having been brought up from below, but possibly drifted on the surface.

The mineral contents of the diamond-matrix or "Blue Ground" of Kimberley (De Beer's, etc.) were described by the late Professor H. Carvill Lewis in the GEOL. MAG. 1887, pp. 22–24.

The diamond-yielding gravel of the Vaal River, partly drifted from the igneous and the old rocks of the higher country on the East, and partly derived from diamantiferous necks and patches, has much analogy to that of the refuse-heaps or washed stuff of the diamond-mines. The constituents of the Vaal gravel, and of that of Dutoit's Pan, are enumerated in the GEOL. MAG. 1871, pp. 55, 56; and Quart. Journ. Geol. Soc. vol. xxviii. 1871, pp. 17–21.

VII.—ON A GLACIAL MOUND IN GLEN FRUIN, DUMBARTONSHIRE.

By DUGALD BELL,
Geological Society of Glasgow.

GLEN FRUIN[1] is a quiet secluded glen, about six miles in length, extending in a north-westerly direction between Lochlomond and the Gareloch, and opening off the neck of land which divides those lochs at between 200 and 300 feet above the sea. To the south-east, it slopes towards Lochlomond, of which the Fruin water is one of the principal affluents. On the west it is divided from the Gareloch by a range of hills 1000 or 1200 feet in height, which at its upper extremity subside into a col or pass of 600 or 700 feet. This upper part of the glen is composed of the mica and clay slates common to the Western Highlands. The lower part is formed of beds of the Calciferous Sandstone series, which have here been faulted down against the older formations.

The upper part of the glen bears every indication of having been at one time occupied by a lake.

A huge boulder of mica-schist, resting on the sandstone, occurs near the foot of the glen, and there are many smaller ones in the same neighbourhood. The respected Convener of the Edinburgh Boulder Committee, the late Dr. Milne-Home, thought this large boulder had been brought by an iceberg (which was his favourite means of transport) either coming down Lochlomond and drifting aside into Glen Fruin, or more probably finding its way over the head of the glen during a period of "great submergence."

The iceberg hypothesis seems to be attended with insuperable difficulties, when we consider (1) where such large icebergs could be formed in the event of so great a submergence as the theory requires; and (2) by what possible main currents of the ocean, which alone could move them, they could be brought to these localities and positions. For these and other reasons, it seems more probable that such boulders owe their transport to a great sheet of land-ice which once filled the glen from side to side, proceeding from the Argyleshire mountains on the north-west, and overflowing the neck or col at the bend of the glen as also that at the head of the Gareloch, between it and Lochlong.[1]

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[1] The "Glen of Sorrow," scene of a sanguinary conflict between the Colquhouns and Macgregors in 1603. (See Introduction to "Rob Roy.")

This view is strongly corroborated by the phenomenon we have now to describe, viz. a remarkable mound of detritus which occurs about half a mile farther up the glen than the large boulder referred to, and extends for a considerable distance in a winding line across the hill-side in a direction from S.W. to N.E., i.e. *transverse* to the glen. It is most conspicuous on the eastern side of the glen, where it runs from 300 to about 500 feet above the sea, "tailing out" on the hill-side towards Lochlomond at a still greater elevation; but it can be traced on the western side also, in the same general direction, though there the ground is lower, and not so favourable for its preservation. It is composed of typical moraine matter—large and small stones, sand and gravel, confusedly mixed together; many of the stones being distinctly striated. Some are sandstones from the immediate neighbourhood; others, schists and quartzes, from greater distances.

The mound varies from 10 to 20 or 25 feet in height, and from 20 to 30 feet in breadth. In some parts it resembles a row of hummocks of varying height; in others it rises from the surrounding moor, distinct and continuous as a railway embankment. A number of boulders, some of considerable size, are perched on its sides or summit, and strewn along its base.

There can be little doubt this is a "terminal moraine" of the great ice-sheet which once occupied the glen; and we may add it is one of the most notable and characteristic which we have seen in the West of Scotland.

A number of detached mounds of considerable size occur at lower levels, beyond the opening of the glen towards Lochlomond, and may be relics of still older moraines.

Meantime the one we have described suggests the following inferences:

1. There has been no submergence to this point *since* the mound was deposited. Its rough, undressed, unstratified condition—its very existence as a distinct mound—proves this. Had there been a submergence of as much as 500 feet since it was deposited, such a loose earthwork would soon have been demolished and effaced by the currents sweeping across this low neck of land between Lochlomond and the Clyde.

2. For the same reason, there could be no submergence to that extent *while* the mound was being deposited. Some geologists hold that the ice-sheet reached the sea as the land rose (assuming a submergence) and laid down such mounds along the sea-margin. In

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[1] As noticed many years ago by C. Maclaren; Edin. New Phil. Journ. vol. xi.

that case they would surely have borne distinct marks of assortment and stratification, especially in localities where strong currents must have been in operation.

3. Nor, finally, is there any proof of a "great submergence" *prior* to these latest works of the ice. This is where the advocates of such a submergence join issue. They maintain that there was a first or general glaciation, then a deep submergence, then a partial or local glaciation, by which all distinct traces of the submergence were removed. But a little reflection will show (*a*) that it is very improbable any subsequent local glaciation could remove all traces of the sea's presence at high levels, supposing it had been there. The sea marks a *horizontal* line and goes into every nook and cranny of the land along the line; whereas the glacier marks a *descending* line, and keeps to one main channel, not branching off in every direction as the waters do. The *area* of the glacier, therefore, could not coincide with that of the submergence so as to remove all traces of the latter.[1] Then (*b*) if such traces *had* been entirely removed

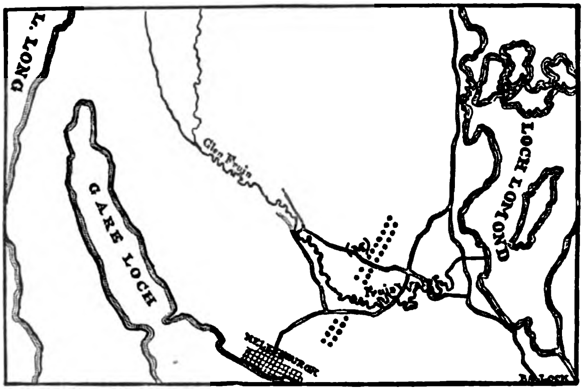

Fig. 1.—Sketch Map showing position of Mound (M.)

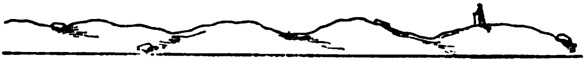

Fig. 2.—General Aspect of the Mound.

from every glen like this Glen Fruin, they should at least be discernible in the heaps of débris which the ice has left near the mouths of such glens. All over the country there are innumerable glacial mounds and heaps—the "sweepings" of glens which, in the case of the alleged submergence, must have been sheltered inlets of the sea, favourable to almost every form of marine life. These heaps, as well as the Boulder-clay of the country generally, should abound in fragments of marine fossils, if there had been such a submergence, instead of being, as they are on the whole, quite destitute of organic remains.

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[1] See Trans. Geol. Soc. of Glasgow, vol. ix. p. 109.

This argument is not founded on a supposition, but on a fact. Wherever the ice can be shown (by the striæ on the rocks, the stones in the "drift," etc.) to have passed over what is still a sea-bed, or what there is no doubt was formerly such, during a very moderate submergence, there also numerous fragments of sea-shells are found in the drift or Boulder-clay; as in the instances of Caithness, Arran, Drymen, South Ayrshire, Holderness, Cromer, Lancashire, etc.

The advocates of the "great submergence" have therefore these two facts to account for: (1) the absence of all proofs of such submergence *in situ* at the high levels to which it is supposed the sea attained; and (2) the absence of all evidence of it in the débris *derived from* these high levels.

REVIEWS.

I.—AN INTRODUCTION TO THE STUDY OF MAMMALS LIVING AND EXTINCT. By WILLIAM HENRY FLOWER, C.B., F.R.S., D.C.L., etc., etc., and RICHARD LYDEKKER, B.A., F.G.S., etc., etc. 8vo. pp. xvi. and 763, Illustrated with 357 Woodcuts. (London, Adam and Charles Black, 1891.)

THE authors of this important Manual have rendered a most valuable service to Biological Science by furnishing us with a book, long wanted, but heretofore not to be met with in any country or language, and one which will be eagerly sought after by zoologists and palæontologists engaged in the study of the higher Vertebrates all over the world.

The few manuals approaching somewhat to this in size, in other countries, are of too popular a character to be compared with the present work. We have some bulky recent works, and smaller manuals too, on systematic zoology, on palæontology, on comparative anatomy, and on the habits of mammals. In the present volume these different details are so happily amalgamated together that we are enabled to gain a good general knowledge of our subject, which a laborious journey through many volumes by various authors would have failed to procure for us.

Originally initiated as a series of articles running through the twenty-four volumes of the ninth edition of the "Encyclopædia Britannica," from 1875 to 1888, by one of the authors (Prof. Flower), the present work has the additional advantage not only of bringing all this information on the Mammalia together, but by the coöperation of Mr. Lydekker, as joint author with Prof. Flower, much new matter relative to fossil forms has been added, and the whole brought up to date, both as to the living and extinct forms.

After a brief introduction of six pages, chapter ii. (pp. 7 to 81) is devoted to the general anatomical characters of the Mammalia; these are written in terse yet clear language, and by the aid of some twenty-four figures in the text are brought within the comprehension of the youngest student of comparative anatomy.

Chapters iii. and iv. (pp. 82 to 116) are devoted to the Origin and Classification, and to the geographical and geological distribution of the class, and will be read with deep interest by all who seek to trace the beginnings of Mammalian life on our earth.

So long ago as 1879 Prof. Huxley came to the conclusion, that in looking among the Vertebrates for the progenitors of the Mammalia we must pass over all known forms of Birds and Reptiles and go straight down to the Amphibia, "they are the only air-breathing Vertebrates which, like Mammals, have a dicondylian skull. It is only in them that the articular element of the mandibular arch remains cartilaginous, while the quadrate ossification is small, and the squamosal extends down over it to the osseous elements of the mandible, thus affording an easy transition to the mammalian condition of those parts. The pectoral girdle of the Monotremes is as much amphibian as it is sauropsidian; the carpus and the tarsus of all Sauropsida, except the Chelonia, are modified away from the Urodele type, while those of the Mammal are directly reducible to it." In 1885 Prof. Cope called attention to the remarkable resemblance to the Monotremes presented by the skeleton of that group of early Secondary reptiles which he then designated the *Theromorpha*, but which may be included in the *Anomodontia* of Sir Richard Owen, and came to the conclusion that in that group we have the true ancestors of the Mammalia.

"Since that date observations made on the structure of the South African Anomodontia have shown such an intimate connexion between this group and the Labyrinthodont Amphibians, that there can be no hesitation in regarding the one as the direct descendant of the other; and we may probably regard the Mammalia as having originated from the same ancestral stock at the time the Amphibian type was passing into the Reptilian. From this point of view, some of the mammalian features found in the more specialized Anomodonts may probably be regarded as having been acquired during a parallel line of development."

In dealing with existing forms of Mammals we find that they have become so broken up into distinct groups by the extinction of intermediate forms, that a systematic classification is perfectly practicable.

When, however, we pass to the extinct world, all is changed. In many cases the boundaries of our groups become enlarged until they touch those of others. New forms are discovered which cannot be placed within any of the existing divisions, and they are no longer sufficient for the purpose, and some other method will have to be invented to show the complex relationships existing between different animal forms when viewed as a whole.

We quite agree with the authors that a linear classification cannot be made to express the many inter-relationships existing between the different families and orders; indeed, as regards many of the fossil forms, it is almost impossible to decide where to place them in relation to living families.

On pp. 107–115 is given a summary of what is known of the Mesozoic Mammals, and on pp. 115–116, a few remarks on Tertiary Mammals; but these are dealt with in greater detail in the subsequent chapters under the heads of the groups to which they are severally allied. "The comparatively scanty evidence of mammalian life hitherto yielded by the Cretaceous (formation), coupled with the number and variety of forms approximating to the existing groups found even in the lowest Tertiary, indicates a great imperfection of the geological record. At present, indeed, we have no decisive evidence of the existence of any members of the Eutherian subclass previously to the Tertiary; but it can hardly be doubted that in some part of the world they had made their appearance before that epoch. The Eutherian mammals of the lowest Eocene, both in Europe and the United States, are of an extremely generalized type; and although many of them approximate to existing groups, they show such a combination of characters, now restricted to individual groups, as to indicate that several of the various orders into which the subclass is now divided were at the period very intimately connected. A marked feature of these early Eutherians is the prevalency of trituberculism in the dentition, not less noteworthy being the frequent occurrence of pentadactylism in the feet, while many of the individual bones were devoid of the grooves and ridges found in those of later types. By the time that we reach the upper division of the Eocene period, such as the horizon of the well-known gypsum of the Paris basin, nearly all the chief groups of mammals had become clearly differentiated from one another, although their representatives were usually more generalized than their existing allies. From this date to the later geological periods there is a gradual approximation to the type of mammalian life existing at the present day."

Turning to the table (pp. 88-92), we find the class Mammalia subdivided into sub-classes, orders and sub-orders, and lastly into families. One hundred and thirty-one families are recorded, of which eighty-six are living and forty-six are extinct. Many of the so-called families of extinct forms are represented by a single genus founded on a fragmentary individual remain, so that, although of extreme interest, they can hardly claim equal taxonomic importance with known families represented by many genera all composed of complete individuals.

We notice a trivial slip (pp. 88–89), Tritylodontidæ being given twice over in the *Prototheria* and in the *Metatheria*. The reference to it under Multituberculata is doubtless correct, and the second (under Marsupialia) may be cancelled.

Owing to the diligence of recent explorers the extinct families known are now fully half as numerous as the living, nevertheless of many of these our information is of the scantiest; nor do they help us to trace the derivation of, or the inter-relationship which we know must have existed in the past between many of the great groups which stand out to-day in strongly-marked distinctiveness from the rest of the class. What, for instance, do we know of the derivation of the Proboscidea? the Sirenia? the Cetacea? or of the Edentata? These are some of the most difficult questions which have to be answered by the modern comparative anatomist and biologist.

Under geographical distribution the authors have adopted the Zoological regions proposed by Mr. Sclater in 1867, but although there are a few instances recorded of change of distribution due to geological causes in late Tertiary times, we may take it that in this part the fossil evidence is omitted. Thus under the Nearctic region, it is stated, "there are, however, no Perissodactyla," whereas *Rhinoceros megalodus* has been described by Cope, as well as numerous other Tertiary forms by Leidy and by Marsh.

We should very much like to see an attempt made to show the geographical distribution of the Mammalia in past times, as well as at the present day. For instance, Dr. Sclater's Palæarctic and Nearctic regions were certainly one, in late Pleistocene times, as the evidence of the Mammalia clearly shows. Thus we have *Rangifer tarandus*, *Alces machlis*, *Cervus elaphus*, and its varieties, *Ovibos moschatus*, *Bison priscus*, with the Lemming, Marmot, tailless Hare, Beaver, Fox, Wolf, Otter, White Bear and Brown Bear, the Mammoth and the Horse spread over all these Northern regions alike in the old and the new world, so that these modern geographical regions only represent the torn-up portions of far wider areas formerly connected. The same holds good of the Ethiopian and Oriental (or Indian) regions, the faunæ of which even now show such strong marks of affinity the one with the other.

Professor Flower is one of those who has advocated more strongly than any other Zoologist the importance of incorporating fossil and recent forms together; but there are not wanting signs in this volume of the difficulties which the authors have felt in attempting this course. In each family the extinct species are carefully kept apart from their recent congeners, a plan which certainly bespeaks the doubts which the authors must have often felt, owing to the imperfect nature of the fossil evidence, of incorporating them in the same series.

For a Second Edition, which will certainly not be long delayed, we venture to offer the following corrections. Among the Rodentia, to the family *Lagomyidæ*, are given $\frac{1}{1}$ or $\frac{3}{2}$ premolars (p. 491), whilst, according to Forsyth-Major, the number of premolars in this family is the same as in the *Leporidæ*, viz. $\frac{3}{2}$, this being the number of the deciduous molars, as observed in *Myolagus Meyeri*, and *M. sardus*; moreover the statement, "molars rootless," does not apply to all the members of the family, as in *Lagodus* (*Titanomys*), which for this, and other reasons, deserves to rank as a genus distinct from *Lagomys*, as well as *Myolagus*, the premolars and molars are both rooted.

In the small space at our disposal it is impossible to give more than a bare idea of the volume before us. Of its usefulness there can be no question, and we may speedily expect to see French and German editions appearing on the Continent.

We heartily congratulate the authors upon the successful issue of their labours; they have produced a book which will greatly advance our knowledge of the higher Vertebrata, and must prove most helpful to the student of Mammalogy; nor can any Library of reference be complete without this most excellent *vade mecum.*

II.—ARMOURED PALÆOZOIC SHARKS.

1. UEBER FLOSSENSTACHELN ODER ICHTHYODORULITHEN IM ALLGEMEINEN. By Dr. OTTO JAEKEL. Sitzungsb. Ges. naturf. Freunde, Berlin, 1890, pp. 119–131.
2. UEBER *MENASPIS*, NEBST ALLGEMEINEN BEMERKUNGEN UEBER DIE SYSTEMATISCHE STELLUNG DER ELASMOBRANCHII. By Dr. OTTO JAEKEL. *Ibid.* 1891, pp. 115–131, with Plate.
3. *ORACANTHUS BOCHUMENSIS*, n.sp., EIN TRACHYACANTHIDE DES DEUTSCHEN KOHLENGEBIRGES. By Dr. OTTO JAEKEL. Zeitschr. deutsch. geol. Ges. 1890, pp. 753–755, Pl. xxxvii.

LAST month we had the pleasure of recording important progress in our knowledge of some Palæozoic Elasmobranch skeletons, due especially to the researches of Dr. Anton Fritsch among the Pleuracanth fishes of the Bohemian Permian formation. On the present occasion we are able to chronicle another interesting advance in the study of allied forms, resulting from the renewed examination of a fossil from the German Kupferschiefer described many years ago by Giebel. It has long been known that certain representatives either of the Elasmobranchii or of the Holocephali, in Palæozoic times, possessed a remarkably developed dermal armour. Hitherto, however, the portions of this armour have almost invariably been found isolated, only few discoveries suggesting that they were fixed upon the head and anterior part of the trunk of the fishes to which they originally pertained. Quite recently Dr. Otto Jaekel has made an interesting contribution to the subject by further extricating from the matrix the supposed Elasmobranch fossil described and figured by Giebel without name in the Zeitschr. gesammt. Naturw. Halle, 1856, p. 367, pls. iii. iv.; and this is identified with a problematical fish very inadequately described by Ewald in the Monatsber. k. preuss. Akad. Wiss. 1848, p. 33, under the name of *Menaspis armata*.

The fossil in question is clearly and concisely described in the second memoir quoted at the head of this notice, and Dr. Jaekel is to be congratulated upon the success with which he has removed the obscuring film of matrix which caused the vagueness in Giebel's original figure. The specimen is but small—perhaps not more than 0·15 in length—and is interpreted as displaying the dorsal aspect to the hinder border of the pelvic fins. The head and anterior part of the trunk seem to have been comparatively broad and depressed; and the pectoral fins were evidently larger than the pelvic pair. There are three lateral pairs of much elongated dermal spines, with recurved tips, fixed upon the head; and a single pair of *Oracanthus*-shaped spines also occurs postero-laterally. Between the pectoral fins there is placed another pair of smaller broad triangular spines; and in the skin of the back there are symmetrically disposed longitudinal series of spinous tubercles. Of the cartilages of the head and trunk nothing is visible; and in the paired fins there are only feeble traces of nearly parallel rays. No median fins can be seen; and the dentition is doubtfully inferred from fragments to have consisted of Cochliodont plates.

Dr. Jaekel was led to the investigation of *Menaspis* by his studies of Ichthyodorulites, detailed in the first and third of the memoirs quoted above. The result is most gratifying to those who recognize in this fossil, as now elucidated, the dawn of our knowledge of the Palæozoic armoured Sharks. At the same time, however, it is much to be regretted that before launching into broad speculations, the author did not further take advantage of the kind offices of Prof. K. von Fritsch, and borrow for study another of Giebel's Kupferschiefer fishes—*Dichelodus acutus.* If this be correctly interpreted in the original memoir (Zeitschr. gesammt. Naturw. Halle, 1857, p. 121, pl. iv.), it affects very materially some of Dr. Jaekel's generalizations concerning "Trachyacanthidæ"; and we venture to think that an examination of it would have considerably modified many matters which we regard as baseless imagination.

Whether, indeed, from an imperfect acquaintance with English, or from defective memory, or hasty work, Dr. Jaekel's theoretical remarks are full of misconceptions, which it may be of advantage in some respects to point out. In the first place, he arranges dorsal fin-spines in three divisions—the "Cestraciont," the "Acrodont," and the "Chimæroid"—according to the form of their transverse section. We would remark that *Nemacanthus* (termed "Cestraciont") and *Ctenacanthus* (termed "Acrodont") have in fact the transverse section and lateral denticles described by Dr. Jaekel as exclusively "Chimæroid"; whereas the dorsal fin-spines of the Myriacanthidæ, which are certainly Chimæroid, present differences again. In the first memoir, too, a whole page is devoted to a fundamental misconception of *Gyracanthus*; but this is cancelled (as the result of an interview with Dr. Traquair) by a footnote in the second memoir. Finally, Dr. Jaekel places all the paired Ichthyodorulites, *e.g.*, *Oracanthus*, *Erismacanthus*, *Physonemus*, *Gampsacanthus*, etc., in a new "group" termed "Trachyacanthidæ" and in the original memoir this is regarded as including both the Cochliodontidæ and the Chimæroid genera, *Myriacanthus* ("*Prognathodus*") and *Chimæropsis.*

The latest researches on the Myriacanthidæ, however, of which Dr. Jaekel overlooked the preliminary results in his first contribution, have caused a considerable modification of the "group Trachyacanthidæ" in his second memoir. *Menaspis* is still retained as a member of the new group, and made, in fact, its type; but the Myriacanthidæ are now declared to be "entirely different." So far all will doubtless be in accord with Dr. Jaekel; but when he raises this group to rank as a distinct division equivalent to—and intermediate between—the "Selachier" and "Chimaeriden," few will be satisfied with the available evidence.

Here, again, several fundamental statements require correction before it is possible to proceed. When the author remarks that unsymmetrical spines never occur in the Selachii, we would inquire in what essential characters the cephalic spines of *Hybodus*, *Acrodus*, and *Asteracanthus* differ from *Erismacanthus*, *Gampsacanthus*, and the slender paired spines of *Menaspis*. Furthermore, the spine named *Myriacanthus granulatus* has never been regarded as a head-spine ("Kopfstachel"), as Dr. Jaekel states: and it is another error to assert that the type-species of the so-called *Prognathodus* has been in part claimed as pertaining to the same fish as *Myriacanthus granulatus*. To suppose that the typical Cochliodont dentition is of an essentially different character ("wesentlich anderes Gebiss") from that of all true Selachii, displays a very superficial acquaintance with existing knowledge of the subject; and when the author suggests that this dentition may have been firmly anchylosed with the supporting cartilages of the jaw ("mit den Kieferknorpeln fest verwuchsen"), we become alarmed by his apparent disbelief in some of the accepted fundamental principles of vertebrate anatomy. A mere reference to literature will suffice to correct the extraordinary mis-statement contained in the expression, "*Placoidei*, Ag. = *Elasmobranchii*, Bonap. = *Chondropterygii*, Cuv. emend. Günth."; and the idea that the calcification of the Elasmobranch endoskeleton always consists merely in a superficial "incrustation," will soon be removed when the author proceeds further in his studies especially of the Palæozoic genera.

Legitimate inference from an array of facts is always a welcome incitement towards new research; but when so many premises are false, theoretical disquisitions are a burden to literature. As long ago recognized by Owen, when he founded the family of Cochliodontidæ, the peculiar dentition of this group of Sharks results only from the fusion of one or more transverse series of teeth into continuous plates, which proceed to grow at the inner border in normal fashion, and curve downwards outside instead of breaking away. Every stage in this process of specialization is known, from the slightly modified *Pleuroplax* to the extremely specialized *Deltoptychius*; and the only remains of the trunk of these fishes hitherto discovered (*Pleuroplax* and *Dichelodus*) conform to the Cestraciont type—not to that of *Menaspis*. As Egerton himself observed in the original memoir, the teeth of the Myriacanthidæ bear much superficial resemblance to the dental plates of the Cochliodonts; and it is thus easy to conceive how they may have been developed at first in a similar manner from a dental armature such as was possessed by the earlier Elasmobranchs. But the teeth even of the Myriacanthidæ are already typically Chimæroid in structure and mode of growth; and to infer from the possession by these fishes of triangular dermal plates, that the Palæozoic Cochliodonts must be somehow related and armed with the ichthyodorulites named *Oracanthus*, etc., seems to us an entirely unscientific procedure. We still remain of opinion that the Cochliodonts are a specialized offshoot of the Cestracionts, and that the Menaspidæ (as the family typified by *Menaspis* ought to be termed) represent some unknown group that yet requires elucidation. Dr. Jaekel has done good service in dispelling a remarkable illusion[1] and in adding some important facts to our knowledge of the armoured Sharks of Palæozoic times; but we will conclude with the hope that in future the author's contributions of this kind may bear signs of maturer study and be less overburdened with reckless speculation.

A. S. W.

III.—MEMORIALS OF JOHN GUNN, M.A., F.G.S.: BEING SOME ACCOUNT OF THE CROMER FOREST BED AND ITS FOSSIL MAMMALIA, AND OF THE ASSOCIATED STRATA IN THE CLIFFS OF NORFOLK AND SUFFOLK, FROM THE MS. NOTES OF THE LATE JOHN GUNN. WITH A MEMOIR OF THE AUTHOR. Edited by HORACE B. WOODWARD, F.G.S., with the assistance of E. T. NEWTON, F.G.S., F.Z.S. (Norwich: W.A. Nudd, 1891.)

FOR the last half century Mr. John Gunn has been a central figure among the geologists of Norfolk, and the present volume is a welcome addition to the records of work accomplished by local observers, to whom British Geology is so much indebted. At the time of his death Mr. Gunn was occupied with a second edition of his "Sketch of the Geology of Norfolk" (contributed in 1883 to White's History and Gazetteer); and a series of plates illustrating the larger Mammalian remains of the Cromer Forest Bed had already been prepared and printed. The MS. was well advanced towards completion, and, by the expressed wish of the author, it was entrusted to Mr. Horace B. Woodward for publication in whatever form might seem most desirable. Mr. Woodward wisely decided not to reprint the earlier "Sketch," which is already accessible, and would have required much alteration in the bringing up to date; but, with the assistance of Mr. E. T. Newton, he only selected such portions of the Supplementary Notes as contained Mr. Gunn's original observations and opinions. A short Memoir of the Author, with a Portrait, and a summary of his work, have been added to these notes; and the series of plates, with the explanatory remarks, form an interesting guide to the Gunn Collection of Forest Bed Mammals now preserved in the Norwich Museum.

The principal items in the biography of Mr. John Gunn were given in the obituary notice in the GEOLOGICAL MAGAZINE of July, 1890 (pp. 331–333). Mr. Woodward's additional notes on some of his papers, however, are worthy of enumeration. Though chiefly concerned with the later formations, Mr. Gunn paid some attention to the Chalk and underlying rocks; and his opinions concerning the Red Chalk and the possibility of discovering Coal-measures beneath the Secondary strata of Norfolk are worthy of respect. The age and relations of the stony bed at the base of the Norwich Crag received much attention from the author, who was especially interested in the Mammalian remains it yielded; and two important sections (one at Bramerton, the other at Coltishall) are reproduced from his unpublished MS. Long-continued researches in connexion with the Forest Bed series and Boulder-clay eventually led Mr. Gunn into wide speculations as to the cause of the Glacial Period; and in his published "Sketch" he treated of still more recent phenomena, making interesting observations on the growth and accumulation of plants in the Norfolk Broads.

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[1] O. M. Reis, Geognost. Jahrb. 1890, p. 30.

Mr. Gunn's own chapters in the volume before us, as might be expected, relate almost entirely to the Forest Bed series. Even to the last his views as to this formation and some of its fossil Mammalia were not altogether in accordance with those of the latest authors; and a table is added to show Mr. Gunn's classification of the deposits as compared with the schemes of Prof. Prestwich and Mr. Clement Reid. It is of great value to have a permanent record of the observations and conclusions of one who made so prolonged and detailed a study of this much-discussed series; and some new woodcuts help to explain the text. The notes on the Mammalia were evidently only just begun, and are thus confined to a discussion of the so-called *Elephas* (*Leptodon*) *giganteus*, *Cervus bovides*, and *Cervus Cromptoni*. None of these names are adopted by Mr. E. T. Newton, who supplies the latest lists of the Forest Bed and Norwich Crag Vertebrate Faunæ; but it is very satisfactory to have a definite statement by the author of the grounds upon which he founded his determinations.

The little volume of "Memorials" is, indeed, a work of far more than local interest; and we commend it to the notice of all who are occupied in studying the latest phase in the geology of the western border of Europe.

IV.—NOTES ON THE GEOLOGICAL SECTION EXPOSED IN THE RAILWAY CUTTING FROM LEVENSHULME TO FALLOWFIELD. Part I. By WM. BROCKBANK and C. E. DE RANCE. Mem. and Proc. Lit. and PHIL. SOC. MANCHESTER, ser. 4, vol. iv. pages unknown, with plate v. in 3 sections: date uncertain, 1891.[1]

IN this section the Upper Measures of the Lancashire Coal-field, possibly the highest Coal-Measures known in England, are seen to underly "Lower Red Sandstone" of Permian age. In the present paper the authors describe the eight groups of limestones with associated marls that form the Upper Coal Measures in this locality. The sixth group from the top is considered to correspond with the Ardwick Limestone of Phillips containing *Megalichthys Hibberti*. Most of these Limestones consist largely of Entomostracan and Annelide remains, and contain numerous coprolites, but not many other fossils. The presence of Hematite produces "beautiful gradations of colour" in both limestones and marls, and we are assured that, in the long coloured section given with the paper, the actual tints are reproduced; to dispel doubts excited by the brilliancy of the plates, this assurance is subsequently repeated. The authors reserve for a future paper the description of the junction of the "Levenshulme Limestones" with the Permian "Collyhurst Sandstone."

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[1] As the Authors' copy, which alone has been sent to us, has been repaged, we are unable to give our readers the correct reference to the original place of publication.

V.—BRITISH FOSSIL BIRDS.

MR. R. LYDEKKER contributes a valuable article on British Fossil Birds to the July Number of "The Ibis," containing a critical summary of present knowledge of the subject. The article occupies pp. 381–410 of the current volume, and treats in succession the birds of the Superficial Deposits, those of the Pliocene Crags, those of the Upper Eocene (Oligocene), those of the Lower Eocene, and the few fragments from the Cretaceous. The researches undertaken by the author for the recently published "Catalogue of Fossil Birds in the British Museum" form the basis of the Memoir; and it constitutes an important readable addendum to the work just cited (see Review of Catalogue in August No. p. 378).

VI.—"PANTOBIBLION: AN INTERNATIONAL BIBLIOGRAPHICAL REVIEW OF THE WORLD'S SCIENTIFIC LITERATURE." Edited by A. KERSHA, C.E. (St. Petersburg and London: Swan Sonnenschein & Co., 1891.)

WE have received the first number of this new monthly, edited and printed in St. Petersburg, and to be obtained in England from Messrs. Swan Sonnenschein & Co. Nearly 300 pages are occupied with classified lists of new scientific works and periodicals, some of which are briefly reviewed. Under the heading "Geology and Mineralogy" we find recorded several Inaugural Dissertations and small separate publications such as are often overlooked by workers. The new periodical will prove most valuable to all engaged in scientific pursuits, and especially to those dealing with applied science.

VII.—MONOGRAPH OF THE FOSSIL SPECIES OF *Pristis*. [MONOGRAFIA DEI *Pristis* FOSSILI CON LA DESCRIZIONE DI UNA NOVA SPECIE DEL CALCARE MIOCENICO DI LECCE.] By DR. GIOVANNI VIGLIAROLO. Mem. R. Accad. Sci. Napoli, [2] vol. iv. append. No. 3, pp. 1–28, with plate. (1890.)

AFTER a definition of the genus *Pristis* and a partially critical synopsis of all known species determined upon the evidence of fossils, Dr. Vigliarolo proceeds to a detailed description of three fragments of a rostrum, from the Miocene of Lecce, preserved in the Geological Museum of the Naples University. The description is illustrated by a large folding plate, and justifies the recognition of a new species, *Pristis lyceensis*. *Sclerorhynchus* and *Propristis* are regarded as extinct genera of Pristidæ, but *Amblypristis* is considered to be merely a synonym of *Pristis*. The known fossils are so fragmentary that they seem to be scarcely worthy the extended treatment they have received at the hands of the author; but the result of his investigations is a useful epitome of our present knowledge of the subject.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

June 24, 1891.—Sir Archibald Geikie, D.Sc., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On Wells in West-Suffolk Boulder-clay." By the Rev. Edwin Hill, M.A., F.G.S.

It might be supposed that in a Boulder-clay district water could only be obtained from above or from below the clay. But in the writer's neighbourhood the depths of the wells are extremely different, even within very short distances; and since the clay itself is impervious to water, he concludes that it must include within its mass pervious beds or seams of some different material which communicate with the surface. It would follow that this Boulder-clay is not a uniform or a homogeneous mass.

The visible sections are only those given, at hand by ditches, and at a considerable distance north and south by pits at Bury St. Edmunds and Sudbury. The appearances in these harmonize with that conclusion. Conclusion and appearances differ from what we should expect on the theory that this Boulder-clay was the product of the attrition between an ice-sheet and its bed.

2. "On the Melaphyres of Caradoc, with Notes on the Associated Felsites." By Frank Rutley, Esq., F.G.S.

Within very limited areas the melaphyres of Caradoc differ considerably in texture and in structure, some having once been basalt-glass or andesite-glass (such being the superficial portions of a lava-stream); others have possessed a certain amount of interstitial glass, which has subsequently been rendered more or less opaque by the development of magnetite, while at times it appears to have been converted into a palagonitic substance. In some of the rocks the crystalline texture is very fine, in others comparatively coarse. Near the summit of Caradoc is a basalt-tuff or andesite-tuff.

The melaphyre or dolerite of Little Caradoc differs from the lavas in that the augite remains fresh and the felspars are altered, while in the lavas of Caradoc proper the pyroxenic constituent is decomposed and the felspars remain as a rule unaltered.

Whether the melaphyre of Little Caradoc may be regarded as a neck from which the lavas lying to the south-west of it emanated, is a point which can only be demonstrated by further field-work.

The author considers that further investigation may prove beyond dispute that the associated felsites are rhyolites of which the original structures have as a rule been almost entirely obliterated. In an appendix further evidence is adduced in favour of the original rhyolitic nature of these felsites, and a fragmental rock from Bowdler's Chair is described as unquestionably a rhyolite-tuff.

3. "Notes on the Geology of the Tonga Islands." By J. J. Lister, Esq., M.A. (Communicated by J. E. Marr, Esq., M.A., F.R.S., Sec.G.S.)

The islands of the Tonga group are situated on a long ridge which rises from deep water on either side to within a thousand fathoms of the surface of the sea. The general direction of the ridge is N.N.E. and S.S.W.

(1) A line of volcanoes, some active, some extinct, traverses the group. Continued southward, the direction of the line passes through the volcanoes of the Kermadec group, and those of the Taupo zone of New Zealand; while to the north it cuts the line of the Samoan volcanoes at right angles.

(2) Besides the purely volcanic islands there are some formed by submarine eruptions, whose layers have been laid out under water and since elevated, with or without a covering of limestone.

(3) The remaining islands are formed entirely of limestone.

Eua is an example of the second group. The volcanic basis consists for the most part of beds laid out beneath the sea, and some of the upper ones contain pelagic shells. Dykes of augite and hypersthene-andesite project on the shore, and a representative of the plutonic series occurs. There is evidence that the island has been elevated and again submerged prior to the elevation which has raised it to the present height. The volcanic basis is largely invested with limestone, and this rock forms the summit 1078 feet above sea-level. Sections show that it is a shallow-water deposit.

Of the purely limestone structures, Tongatabu, Nomuka, and the long reef on which the larger islands of the Hapaii group are situated, form more or less complete atolls, all of which have been elevated to a greater or lesser extent.

The Vavau group is remarkable for its very indented contour, suggesting the idea that it rests on a much denuded basis. Both here and at Eua there are raised limestone formations with atoll or barrier-like contours; and there is some direct evidence to show that these have been formed without the aid of subsidence.

The presence of islands formed of volcanic materials laid out in layers beneath the sea, and the manner in which the recently formed Falcon Island is now being reduced to the condition of a submarine bank, suggests that the atolls of the group may rest on similarly formed foundations.

4. "On the Inverness Earthquakes of November 15th to December 14th, 1890." By C. Davison, Esq., M.A. (Communicated by Prof. Charles Lapworth, LL.D., F.R.S., F.G.S.)

In this paper the author gives reasons for supposing that the Inverness earthquakes of last year were due to the subsidence of a great wedge of rock included between a main fault and a branch one; and he considers that there is little doubt that these recent earthquakes were the transitory records of changes that, by almost indefinite repetition in long past times, have resulted in the great Highland faults.

The next meeting of the Society will be held on Wednesday, November 11th, 1891.

CORRESPONDENCE.

THE SUPPOSED DICYNODONT FROM THE ELGIN TRIAS.

SIR,—At the meeting of the British Association at Aberdeen in 1885, much interest was excited by the alleged discovery of *Dicynodon* in the Triassic sandstones of Elgin. Professor Judd stated his belief in the specimen at the time ("Nature," Oct. 15, 1885, p. 573), and said that the specimen was in the hands of Dr. Traquair. In Woodward and Sherborn's "Catalogue" (1890) I notice these authorities place a (?) before the reference, thus indicating the doubtful nature of the find, while Lydekker in vol. ii. "Manual of Palæontology" does not even refer to it. Are we to interpret Dr. Traquair's six years' silence as a withdrawal of the original determination? When an important discovery has been announced, it seems only just that the geological public should hear more about it, and this practice of throwing out vague and unsatisfactory statements is very annoying to those who prefer exact information and rather disparaging to the discoverer, who naturally expects so great a find to be worthy of notice. G. ROPER.

ON DYNAMO-METAMORPHISM.

SIR,—I think Dr. Irving has not quite understood the reasoning in my short article on Dynamo-metamorphism of a year ago. I wrote, that the part of the work of compression expressed by the product $(P-W)\,w$, where P is the compressing force upon a cubic element of the disturbed mass, W the weight of the cover, and w the height through which the cover has been lifted, was employed in bending and breaking the rock and overcoming friction, and that, since this part of the energy is not reconvertible into mechanical work, it must take the forms of heat and chemical action. He thinks this "last term is surely outside the others altogether"; that is, I suppose, is employed upon the rock external to the portion of it under consideration. But the expression is not very clear, though his illustration in the note (p. 300) seems to show that such is his meaning. He says there that, if a horse or engine draws a series of loaded trucks along a perfectly horizontal line of rails, "work is done in overcoming the friction of the wheels against their axles and against the rails, and in the displacement of a portion of the atmosphere with the movement of the train; but would any one contend that energy was stored up in the train?"

Energy of motion is so obviously stored up in the train that Dr. Irving cannot refer to that. He must refer to the energy imparted to the atmosphere, and to the energy absorbed by friction, which last is distributed between the trucks and the rails. The energy communicated to the air is "outside" the other effects, and so is the energy absorbed by the rails. But the energy absorbed by the friction of the wheels against their axles is partly converted into heat, and is partly employed in producing a molecular change in the iron, rendering it more granular and liable to fracture. I should consider this a case of dynamo-metamorphism. Still it appears to me that the illustration is not apt. The amount of work to which I refer must be expended on bending and breaking the *particular mass* of rock under consideration, and in shearing the parts of it past one another, and not on the rock outside of it. Hence the energy which is its equivalent has been introduced into the mass; and, energy being indestructible, none of it is lost, and there is now more energy in the mass than there was before. The question which I proposed was simply, what form does that energy take? Is it heat? or is it, as I (perhaps rashly) enquired, chemical energy?

Dr. Irving says that both Mr. Harker and myself have overlooked the one great factor of metamorphism, viz. superheated water. I do not think we either of us proposed to discuss all the causes of metamorphism, but only the mechanical. O. Fisher.

Harlton, Cambridge, 11 *July*, 1891.

DYNAMO-METAMORPHISM AGAIN.

Sir,—A short space will suffice for what I have to say in reply to Dr. Irving (p. 296). I am sorry to have misunderstood, or, as he phrases it 'misrepresented,' him as assuming that the whole of the work passes into heat. I am not sure that even now his position is clear to me. His dictum "chemical combination must generate heat" is intelligible, though, as Mr. Fisher has pointed out, by no means universally accepted by chemists; but simple combination does not cover any of the chemical changes that characterize the metamorphism of rocks. These are "much more complex," and if Dr. Irving believes that in these cases there is always, on the balance, a positive amount of heat generated, he believes that for which no proof whatever is offered.

It is possible that some of the differences between Dr. Irving and myself would resolve into a question of words, if his language were more intelligible to me; but unfortunately his usage of physical terms often bears no relation to the definitions in use among physicists. "Intensity of heat" seems to mean temperature, but what are we to make of the expression (used in taxing another correspondent with confusion of thought) "the energy is presented in the mechanical form of pressure"? The simple word 'deformation' also appears to be employed in some occult sense.

The experiments of Cailletet and Pfaff which I cited are the same as those referred to in the "Report on Slaty Cleavage" mentioned by Dr. Irving. They seem to establish that increased pressure retards chemical changes involving a diminution of density, while Spring's researches tend to show that pressure assists changes involving an increase of density. The two conclusions appear to me not contradictory, but complementary parts of one law. As regards Spring's experiments, Dr. Irving has ludicrously misunderstood me when he implies that I deny the generation of heat by friction during the compression. What I said was that the heat so generated was carefully removed (by conduction). As Major-General McMahon points out (at p. 90 of this volume), M. Spring himself seems to have changed his views as regards the significance of his work, but the published details of his experiments leave others free to draw their own conclusions from them. Kroustchoff's interesting synthetic production of hornblende and other minerals do not seem to throw any new light on the problems in hand.

ALFRED HARKER.

OBITUARY.

DANIEL MACKINTOSH, F.G.S.

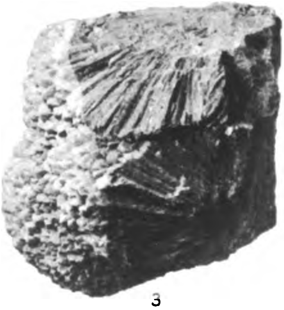
BORN 1815. DIED 19 JULY, 1891.

WE regret to announce the death of Mr. Daniel Mackintosh, F.G.S., who was born in the memorable year 1815, at Blairgowrie, in Perthshire, where his father had a mill worked by water-power. Imbued with an early love of Natural Science, he left Scotland when about 30 years of age. For many years he was a lecturer on Scientific subjects and well known in the south of England, where he lectured at various public institutions and schools on Astronomy, Geology, Physical Geology and Ethnology with considerable success. His manner as a lecturer was clear and spirited, and aroused an interest in the subjects of which he treated.

Mr. Mackintosh was elected a Fellow of the Geological Society in 1861, and contributed his first paper on "Terminal Curvature" in 1867, and afterwards numerous papers to the Society on Surface Sculpture, Denudation, Drift Deposits and the Dispersion of Erratic Blocks. Many of his papers are in the "Reports of the British Association," and the "Proceedings" of Societies of which he was a member. He was a frequent contributor to the GEOLOGICAL MAGAZINE, and other scientific publications.

In 1869 Mr. Mackintosh produced his work on "The Scenery of England and Wales," in which he favoured the action of the sea as the greatest denuding agent, and it is illustrated by 86 sketches of geological interest. He received four successive grants in aid of Original Scientific Research, from the Government Grant of the Royal Society. In 1881, he was presented with the Kingsley Memorial Medal of the Chester Society of Natural Science, and in 1886 was awarded the proceeds of the balance of the Lyell Fund by the Geological Society, in recognition of his studies of the Glacial and other Superficial Deposits of the north-west of England.

About 20 years ago Mr. Mackintosh went to reside at Chester, but a few years after he settled in Birkenhead, and was president of the Liverpool Geological Society during 1881–3. In recent years he devoted much time to the examination of the Drift Deposits and Boulders of North Wales, and during his last exploration ascended Cader Idris when nearly 70 years of age. Soon after he began to fail in both mind and body, and died on the 19th of July last, and his remains now rest in Flaybrick Cemetery, Birkenhead, close to the glaciated areas he so frequently visited and described. His papers on the Glacial Deposits will hold a permanent place in geological literature, and he will be remembered for his kind and gentle disposition by all who came in contact with him.—G. H. M.



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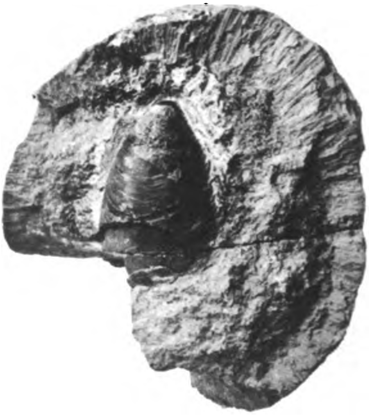

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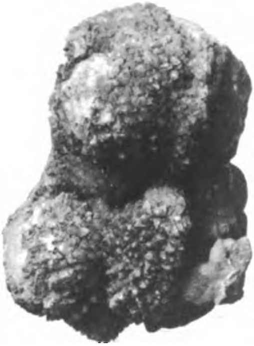

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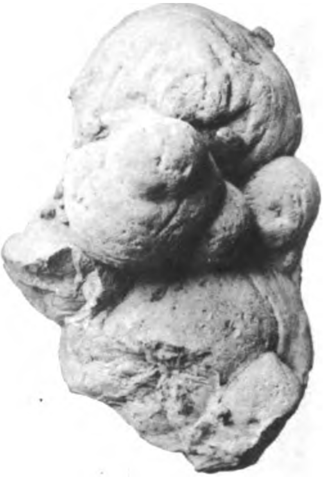

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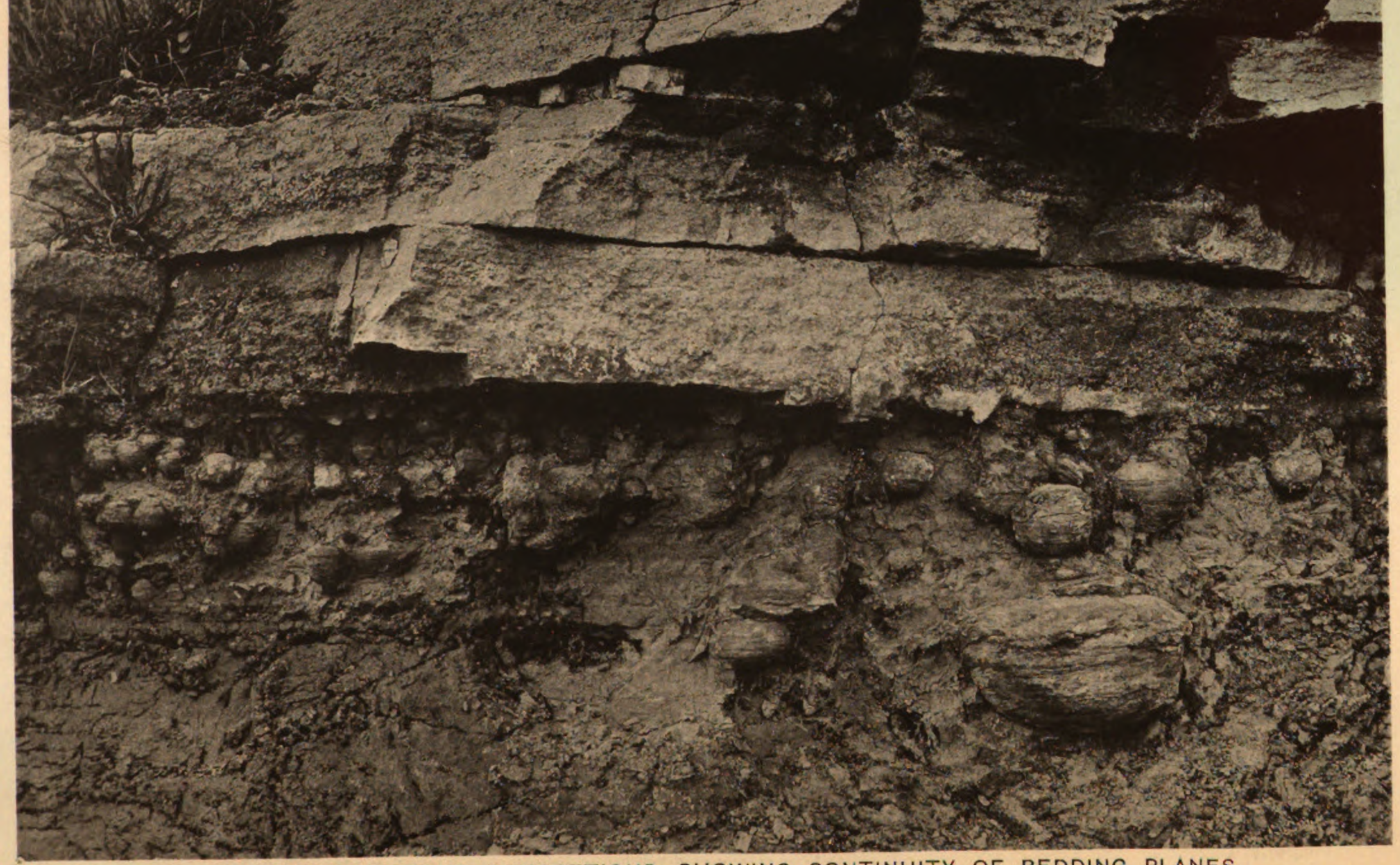
CONCRETIONS

FROM THE

MAGNESIAN LIMESTONE OF DURHAM.



MAGNESIAN LIMESTONE CONCRETIONS, SHOWING CONTINUITY OF BEDDING PLANES.
MARSDEN QUARRIES, COAST OF DURHAM.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE III. VOL. VIII.

No. X.—OCTOBER, 1891.

ORIGINAL ARTICLES.

I.—On the Origin and Mode of Formation of the Concretions in the Magnesian Limestones of Durham.

By E. J. Garwood, B.A., F.G.S.

(PLATES XII. and XIII.)

IN 1826, 27, and 28, Prof. Sedgwick contributed to the Geological Society of London his classical papers on the Magnesian Limestone of the East of England,[1] in which he describes in detail the concretionary structures which occur in many of the beds of this formation in Durham.

Although he describes these concretions in minute detail, he says but little as to their probable origin, but it is clear that he regarded them as composed of carbonate of lime derived from the beds in which they occur, when he says—"The particles (of lime), after deposition, appear to have run into lumps and masses more or less crystalline, rejecting great portions of the earthy residuum."[2] Since Prof. Sedgwick's papers little seems to have been contributed to the subject of the mode of formation of these concretions.

Two opposite opinions are held with regard to the proximate source of the carbonate of lime:—One to the effect that the lime was introduced into the concretionary bed subsequent to its formation, in solution from without; the other that it was deposited contemporaneously and subsequently segregated out *in situ*.

The latter opinion is, we believe, that generally held,[3] though there are some who advocate the former, which may be called "the Stalactitic"[4] theory.

Looking at the Magnesian Limestone series as a whole, many of the concretionary structures appear as if they might have been formed in the stalactitic manner supposed; but when the individual beds containing the concretions are studied in detail, they are found to present many points which appear irreconcilable with the theory of their stalactitic origin.

The locality where these beds can be most satisfactorily examined is at Marsden quarries on the coast of Durham, between Sunderland and South Shields, where masses of stratified limestone are interbedded with marls containing concretions in every stage of development. Where fully developed, the concretions assume a spherical form, and are sometimes as much as 1 to 2 feet in diameter, the average size being from 3 to 6 inches. They are composed of fibrous crystals of calcite radiating symmetrically from the centre, which frequently consists of a valve of *Ascinus dubius* or *Myalina Hausmanni*. (See Plate XII. Fig. 1.) Very often, however, the centre is composed merely of a small cavity.

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[1] Prof. Sedgwick, "On the Geological Relations and Internal Structure of the Magnesian Limestone," Trans. Geol. Soc. London, 2nd series, vol. iii. 1835.

[2] *Op. cit.* p. 89.

[3] Prof. Green, Physical Geology, p. 279; Geikie, Textbook of Geology, 1885, p. 472.

[4] R. Howse, "On the Stalactitic Origin of Conglobated Structures in the Magnesian Limestone," Tyneside Naturalists' Field-club, October, 1889.

These concretions occur in irregular masses 20 to 30 feet thick, showing here and there rough stratification, and often passing laterally into well-bedded limestone. Many of the larger specimens show well-marked concentric bands developed at regular intervals.

The concretions are piled on one another with but scant matrix between; chemically they consist of 91 to 95 per cent. of carbonate of lime and 1·5 to 4 per cent. of magnesia.

It is difficult to see how such masses of limestone could have been formed by infiltration from beds above. Where are the beds into which the carbonate of lime dripped during the formation of the concretions? If we suppose these concretions to have been formed from carbonate of lime introduced in solution from an overlying bed subsequent to the consolidation of the deposit in which they occur, then the original bed, now replaced by concretions, must have disappeared. But this bed would originally contain 20 to 30 per cent. of magnesia, which must have been subsequently dissolved out; yet it is hardly likely that water which was saturated with carbonate of lime would dissolve out carbonate of magnesia the less soluble salt of the two,[1] and we cannot suppose that the magnesia bed was dissolved out first, leaving an enormous cavity into which the carbonate of lime afterwards dripped, forming around shells suspended in some mysterious manner; the symmetrical development of the concretions also, which is as perfect vertically upwards from the nucleus as it is laterally and vertically downwards, seems to preclude the possibility of their having been formed in a previously-solidified rock-mass.

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Again, the shells forming the nucleus of the concretions are often in beautiful preservation, which is hardly likely to have been the case if they had lain in a porous bed exposed to the action of infiltrating waters, while in those cases where the centres are hollow it is impossible for the carbonate of lime trickling through the beds in solution to have crystallized out round a cavity, whereas we can easily imagine the centre to have originally consisted of an organic body in the sediment which, serving as the nucleus round which concretionary action was set up, afterwards decomposed.

But it is in the beds containing immature concretions in various stages of growth that the strongest arguments against the formation of the concretions by stalactitic action are supplied.

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[1] Hardman, Carbonif. Dol. of Ireland, Proc. Roy. Irish Acad. vol. ii. ser. 2, 1877.

These beds consist of friable yellow marl, in which are imbedded hard sphæroidal concretions often much flattened. The concretions consist of 85–95 per cent. of carbonate of lime, and 6 to 12 per cent. of magnesia, while the matrix often contains as much as 50 parts of magnesia on 100 of carbonate of lime.

The beds are markedly stratified, the lines of bedding passing uninterruptedly through matrix and concretions alike. (See Pl. XIII.)

This fact was first noticed by Prof. Sedgwick, and it is perhaps the strongest argument in favour of what we may call the 'Segregation' theory. The advocates of the 'Stalactitic' theory refer these lines of stratification in the concretions to lines along which the carbonate of lime spread out when dripping from above in solution; but this does not account for the individual lines of bedding passing uninterruptedly from matrix to concretion, nor does it account (if the formation is still supposed to be taking place) for the fact that where the beds dip at a considerable angle, the lines in the concretions are still parallel to the general bedding of the rock, not parallel to the horizon, as would be the case if they were being formed up to the present day by infiltration.

These flattened concretions contain numerous small shells disseminated through them, notably *Pleuropterus costatus* and *Turbo helicinus*, whereas these appear to be altogether absent from the matrix. This we should expect according to the 'Segregation' theory, the shells being the nucleus round which the carbonate of lime segregated, and any fossils remaining in the matrix, which is extremely porous, would, after the solidification of the bed, be readily dissolved out by subsequent infiltration, whilst those embedded in the concretions would be protected by their impervious covering of hard limestone.

These fossils are frequently found projecting from the sides of the concretion along lines of bedding, in the same way that one-half of a sponge spicule, or other organic body, is found embedded in a flint, while the other half projects into the surrounding chalk.

It is difficult to account for the presence of fossils in these flattened concretions if we assume their stalactitic origin, as we cannot suppose them to have been introduced in solution, and to have reformed as fossils on the solidification of the concretion.

Turning now to the chemical side of the question. It had been hoped that a detailed chemical investigation of these beds would have conclusively proved by which of the two processes under consideration these concretions had been formed. For supposing the average analysis of the beds containing concretions to have agreed with the analysis of beds containing no concretions, we should have been justified in concluding that the carbonate of lime, of which the concretions are mainly composed, had not been introduced from overlying beds in solution, but had been originally deposited as part of the bed in which they are now found; but the complicated nature and variable chemical composition of the different beds of the series cause the evidence so afforded to be less certain than had been hoped, although the results are by no means valueless in this connexion.

The great drawback to the evidence is the very variable composition of those beds in which no concretions are developed, and the difficulty of selecting a bed or beds representing the original composition of the deposit, as regards the relative quantities of carbonate of magnesia and carbonate of lime present. In the annexed table are given average analyses of concretionary, stratified, and compact magnesian beds:—

	I.		II.		III.		IV.		V.	
	Matrix.		Concretions.		Average of I. and II.		Overlying Bed.		Roker Cliff. 100 feet.	
Carb. Lime ...	46·07	100·00	86·14	100·00	59·43	100	85·78	100	59·81	100
Silicate	2·03		·26		1·50		·09		—	
Carb. Magn....	30·68	66·74	9·5	11·0	23·62	40	6·5	7·5	26·06	43
Peroxide Iron	1·52		1·8		12·60		2·0		14·13	
Alumina	16·58						3·15			
Insol. in HCl.	3·00		1·98		2·5		2·10			
	99·88		99·68		99·65		99·62		100·00	

Column I. gives an average of 12 analyses of the matrix which are each tested from 15 samples, the composition shown being thus the average of 180 samples. In the same way Column II. shows the average composition of 180 samples of the concretions.

The bed selected for examination is that shown in the photograph, (Plate XIII.), which extends for some 12 to 15 feet in a downward direction. It will be seen that whereas the matrix contains 66, the concretions only contain 11 parts of magnesia to 100 parts of lime.

The overlying bed (No. IV. of the Table) is a well-bedded limestone, which forms the surface beds in this district, and if the concretions had been formed stalactitically, it is from this bed that the lime must have been derived; but the bed shows no honeycombed appearance, and is one of the most compact members of the series. This overlying bed, which is 20 to 30 feet thick, is itself thoroughly concretionary in its structure, although on a minute scale, on the type of the globular concretions which overlie and pass into it, and if the lime forming the concretions is to be regarded as derived from infiltration, the whole of this upper bed must then have been formed in like manner, for we cannot fix an arbitrary size of concretion and declare that all those larger than this size were formed by infiltration and all those smaller, although of exactly similar structure, represent the bed as originally deposited. Since then the beds immediately overlying our concretionary bed are also concretionary, we cannot consider them as representing (according to the stalactitic theory), the original deposit, and we cannot use them therefore for instituting a chemical comparison with the typical concretionary beds. If, however, we go to higher beds, omitting those which have concretionary limestone interbedded with them, we find at Roker a massive bed nearly 100 feet thick; its composition, as given by Messrs. Browell and Kirkby,[1] is shown in Column V. of our Table.

In order to compare the composition of this bed with that of our bed of concretions, we must obtain the average composition of the latter, and to do this we must determine the relative proportions of concretions and matrix present. Numerous estimates along the exposure give roughly 2 of matrix to 1 of concretions as the approximate proportions, and working this out (Column III. of the Table), it gives us 40 parts of magnesia to every 100 parts of carbonate of lime, which will be found to agree very closely with the analysis of the Roker bed, which gives 43 parts of magnesia to 100 of carbonate of lime.

This entirely confirms the theory that the lime composing the concretions was derived from the beds in which they occur, and was not introduced subsequent to their deposition. We must, however, frankly acknowledge that there are two uncertain factors in this comparison, namely, the difficulty of arriving at an exact estimate of the relative proportions of matrix and concretions, and the somewhat arbitrary selection of the bed with which they are compared; as, however, great importance has been attached to a detailed chemical investigation of these beds, we give the results of our work in this direction, which confirm, as far as they go, what we have before alluded to as the 'Segregation' theory.

There is, however, other evidence in this direction derived from a study of the chemical composition of the concretions, namely, the presence in them of magnesia and insoluble matter.

The amount of magnesia, which is sometimes as much as 12 per cent., varies considerably in different concretions in the same bed, analyses of two concretions lying a few feet apart yielding in one case 2·3, and in the other 6·3 per cent. If the concretions had been deposited from percolating water, it is difficult to see why the water should vary at the distance of a few feet in the amount of magnesia it contained, whereas on the segregation theory we should expect the amount of impurities imprisoned during the process to vary from point to point, and it is still more difficult to account for the presence of insoluble matter, which is usually about 2 per cent., and in one specimen amounts to as much as 8·5 per cent. of the concretion.

The last argument against the stalactitic origin of this deposit that we have to bring forward is the fact that large quantities of calcite occur in these beds which *have* undoubtedly been formed by stalactitic action. They consist of pure white fibrous calcite,[2] and contain no magnesia or insoluble matter, they line cavities and cracks, and fill in the interstices between the concretions, often coating their surfaces to the thickness of an inch, and roughly modelling themselves on their external shape. These deposits, which here and there attain a thickness of 5 to 6 inches, can be traced to joints in the overlying beds through which the carbonate of lime has undoubtedly obtained access in solution, the walls of the joints

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[1] Browell and Kirkby, on "The Magnesian Limestone of Durham," Nat. Hist. Trans. of Northumberland and Durham, vol. i. pt. 2.

[2] Not aragonite, as often described locally.

being lined with a similar deposit. Figs. 3 and 4, on Plate XII., show concretions coated with it. In many cases (Fig. 4) the calcite has begun to replace the original concretion, or perhaps add to its original mass, but this replacement is limited to about a quarter of an inch on the surface, and it never penetrates far, except when it fills cracks in the concretion. It is obvious, then, that it is either replacing the concretion from without inwards, or is forming on the surface of previously existing concretions, and its secondary nature is quite unmistakeable.

Summary.—We can then sum up the evidence against the stalactitic origin of these concretions under the following heads:—

I. *Stratigraphical.*—(*a*) The marked stratified condition of these beds as a whole, which would to a large extent have been obliterated by the copious infiltration necessary for the formation of the concretionary structures.

(*b*) The uninterrupted passage of the lines of bedding through matrix and concretions alike.

(*c*) The enormous thickness of some of the concretionary limestones.

(*d*) The fact that the concretions occur only in the Upper Magnesian Limestone, which is overlaid by the Triassic Marls and Sandstones, a deposit containing originally probably but little carbonate of lime.

(*e*) The fact that the concretions are confined to the Magnesian Limestone series.

II. *Evidence from fossils.*—(*a*) The occurrence of shells in the centre of the radial concretions.

(*b*) The occurrence of cavities at the centre, probably originally occupied by organic matter.

(*c*) The wonderful state of preservation of shells occurring in these concretions and the almost total absence of fossils from the earthy matrix.

III. *Chemical.*—(*a*) The great similarity in composition between the concretionary bed as a whole, and the massive beds higher in the series which contain no concretions, with reference to the relative amounts of carbonate of magnesia and carbonate of lime that they contain. Showing that it is unnecessary to assume the introduction of extra carbonate of lime from beds above.

(*b*) The variable amount of magnesia in contiguous concretions.

(*c*) The presence in the concretions of a considerable quantity of insoluble material.

(*d*) The presence of calcite in these beds which *has* undoubtedly been deposited by stalactitic action and which in appearance, composition, and behaviour is so dissimilar to these concretions.

Having shown that the carbonate of lime of the concretions has in all probability been derived from the beds in which the concretions occur, we should like to add a few words as to the manner in which they appear to have been produced.

That some of the carbonate of lime disseminated through the deposit was abstracted from the general mass, and segregated round definite centres of attraction, is doubtless true, and, as Prof. Green remarks, we may give to this process a name of its own and call it

"Concretionary Action," but it does not enable us any better to realize the immediate cause of the process, or to understand the manner in which it was brought about. With regard to the first part of the problem, namely, the cause of the segregation, the following considerations may throw a little light on the subject.

The concretionary beds are usually crowded with fossils, and it is round these fossils that the carbonate of lime has segregated out; they, together with other foreign bodies (probably for the most part organic particles, and now represented by cavities), were the, so to speak, chemical magnets which attracted to themselves the available carbonate of lime.

The Roker beds, on the other hand, which are quite unfossiliferous but are, as shown above, approximately identical in composition, contain no concretions.

It might be urged against this that the Middle Limestone, which contains the most numerous assemblage of fossils in the whole system, has developed no concretions; but those beds contain a relatively large proportion of carbonate of magnesia to carbonate of lime, which, as we are about to point out, seems also to have influenced the decision as to whether a certain bed should or should not develope concretions.

The presence of carbonate of magnesia in the unconsolidated deposit appears up to a certain point to have assisted the segregation of carbonate of lime; but when the quantity of magnesia present reached over 30 per cent., it has prevented this segregation from taking place, except in small local patches. On the other hand, in those beds which are composed of almost pure carbonate of lime, the concretionary structure is only developed in a minute form throughout the mass.

It would appear, then, from this that where the deposit was fairly free from magnesia, the "concretionary action" started from so many centres, that no centre had time to aggregate more than a small quantity of lime to itself, before it came in contact with the growing peripheries of neighbouring concretions, and its further growth necessarily ceased. When, however, the deposit contained more magnesia, the particles of lime were consequently more widely separated, there was less inducement for individual effort on the part of would-be centres, and only the larger and stronger ones succeeded in attracting particles from the surrounding mass, and grew in size in proportion to their numerical scarcity; the distance from which they were able to draw particles increasing in proportion with the increase of their mass. When, however, the proportion of magnesia present exceeded a certain amount, the distance between the particles of lime became so great, and their mutual affinity was so weakened by this increased separation, that no foreign body was sufficiently powerful to start the migration of particles in its own direction, and the deposit solidified as an ordinary compact bed.

We have then in concretionary action a very analogous process to crystallization. When the solution of a salt is concentrated and allowed to stand, it rapidly crystallizes, forming a mass of small crystals. If, however, the solution had been previously diluted, fewer and larger crystals would have been formed, and this dilution might have been carried to a point, after which further dilution would have prevented crystallization from taking place altogether.

That the presence of magnesia is the primary cause of the formation of the concretions is borne out by the fact that they are confined to this formation, although there are plenty of other limestones in the geological sequence in which they should otherwise have occurred. We may remark in passing that no argument in favour of the 'Stalactitic' theory can limit the application of that theory to these particular beds, for the character of the deposit into which the lime is supposed to have been introduced could have no influence whatever in causing that lime to be dissolved from the beds above.

The second part of the question, namely, the process by which the particles of lime were conveyed from their original positions in the deposit, and were aggregated round their respective nuclei, is a very difficult one to answer, and we do not appear to have advanced much towards the right understanding of this process since the days when Prof. Sedgwick wrote. Broadly, the process is comparable to the solution of sponge spicules in the chalk, and their redeposition round nuclei in the form of flints.[1] Carbonate of lime, and silica are, however, different material. What do we know about the pectous and colloid forms of carbonate of lime? It is true that the aragonite forming the shells of mollusca is an animal product, and may perhaps be analogous to the form of silica known as organic; and we know that it is frequently converted into calcite in fossil shells, showing that a rearrangement of the molecules of carbonate of lime does take place after the entombment of the shell. The carbonic acid and other gases given off from the decomposing organic matter in the deposit, and existing under considerable pressure, have probably played an important part in maintaining the particles of carbonate of lime in a state of molecular suspension, in which condition they were able to migrate to the nucleus which was irresistibly attracting them. Whether this state was one of true solution as usually understood, or whether it was one analogous to the colloid condition of silica, it is impossible to say. Recent experiments on the combination of solids under pressure, and the movement of the individual molecules of a dry mixture, show that more rearrangement probably takes place amongst the particles of an unconsolidated deposit than we are accustomed to imagine.

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[1] W. J. Sollas, Ann. and Mag. of Nat. Hist. 5th series, vol. vi.

II.—THE RECENT AND RAPID ELEVATION OF THE AMERICAN CORDILLERA.

By HENRY H. HOWORTH, Esq., M.P., etc., etc.

IN some papers which have lately appeared in the GEOLOGICAL MAGAZINE, I have endeavoured to show that the Ural Mountains, and also the great masses of high land in Eastern Asia from the Altai to the Himalayas, are of very recent geological origin, and that it was probably their rapid elevation which caused the great diluvial movement of which traces are to be found all over the Siberian plains. I now wish to call attention to some of the evidence which points to the American Cordillera being also a very recent geological feature, and dating from the same period of cataclysmic revolution which closed the Mammoth age.

It is a curious fact that one name, America, connotes both of the great continents hung together by the isthmus of Panama. The cause of this is of course purely historical, and yet it coincides with a great physical fact, namely, their essential unity in more than one respect. The generic unity of the old inhabitants of both continents is a peculiar fact in ethnography; but the unity is even more remarkable in this, that the vertebral column which runs north and south through the two Americas is essentially one backbone.

On this subject Humboldt writes with his usual lucidity and force. Speaking of the great chain of mountains that runs through both continents, he says: "This is the most continued, the longest, the most constant in its direction from south to north, and north-north-west, of any chain of the globe. It approaches the north and south poles at unequal distances of from 22° to 33°. Its development is from 2800 to 3000 leagues (20 to a degree), a length equal to the distance from Cape Finisterre in Galicia to the North-East Cape (Chukchoi-Noss) of Asia. Somewhat less than the half of this chain belongs to South America, and runs along its western coast. On the north of the isthmus of Capica and of Panama, after an immense lowering, it assumes the appearance of a nearly central ridge, forming a rocky dyke that joins the great continent of North America to that of the South. . . . As the continent beyond the parallel of Florida again widens towards the east, the Cordilleras, of Durango and New Mexico as well as the Rocky Mountains, which are a continuation of those Cordilleras, appear to be thrown anew towards the West, that is, towards the coast of the Pacific Ocean; but they still remain eight or ten times more remote from it than in the southern hemisphere. We may consider as the two extremities of the Andes, the rock or granitic isle of Diego Ramirez, south of Cape Horn, and the mountains that reach the mouth of the Mackenzie River (lat. 69°, long. 130½°), more than twelve degrees west of the Green Stone Mountains, and known by the denomination of the Copper Mountains" (Humboldt's Narrative, vol. vi. pp. 409–411).

It is to this chain chiefly that I wish to direct your readers.

The first and most remarkable fact to which I would draw attention is that throughout its vast length (in places towering to an enormous height) there are only slight traces to be found of ancient glacial action, *except in* the length which separates Chili and Patagonia. Excluding this length, there are hardly any scratched boulders, roches moutonnées, or polished or striated surfaces which we can assign to that vast ploughshare of ice which has left its mark so plainly written on the flanks of the Alps and the Dovrefelds, the granite wastes of Labrador and the North-Eastern parts of America. Upon this point the best observers are unanimous.

We will first turn to South America.

It was Darwin who first drew attention to the distribution of boulders in South America. Humboldt had argued that, inasmuch as they are never found in the great intertropical plains of the Eastern side of America, they are entirely absent from the whole continent. Referring to this conclusion, Darwin says: "As far as I am able to discover from the works of travellers, and from what I have myself seen, the remark holds good in the countries on both sides of the Cordillera as far south as Central Chile. Azara has particularly stated such to be the case in Chaco. With respect to the tributaries of the Amazons, nothing can more strongly prove it than La Condamine's story" (Darwin's Narrative, p. 289). He says: "Below Borja even for 400 or 500 leagues, a stone, even a single flint, is as great a rarity as a diamond would be. The savages of those countries do not know what a stone is, and have not even a notion of it. It is diversion enough to see some of them when they come to Borja, and first meet with stones, express their admiration at them with signs, and be eager to pick them up, loading themselves therewith as with a valuable merchandize. . . . Neither in the southern nor in the northern hemisphere do the fragments, coming from the Polar regions, or from other mountain groups, arrive within a considerable distance of the lines of the tropics" (Darwin's Narrative, pp. 288–9). In the Appendix he says: "The lowest latitude in South America, in which I found large angular fragments, which must have been transported by ice there formed, or by some unknown means, was in latitude 41°. But as I did not examine the country immediately north of it, I am not prepared to say that this is their extreme limit, but between latitude 27° and 33° I found no appearance, on either side of the Cordillera, which indicated a power of transportation of the kind required to remove boulders from a distance. Thus we find that the limit of their dispersion in the two Americas is nearly the same" (*id.* p. 615).

Darwin curiously compares the Andes with the Himalayas in this respect. Thus he says: "We must couple the absence of erratic blocks along that part of the Andes which is situated under a warmer climate, with the similar non-occurrence, as I am informed by Prof. Royle, in Northern India round the flanks of the Himalaya, those loftiest pinnacles on the face of the globe" (*id.* p. 289).

What is true of South America is true of North America also. I must not be misunderstood. I am only speaking of the Rocky Mountains proper, which also are treated by Humboldt as in essence identical with the Andes. I do not include the so-called Coast Range or the Cascade Mountains, or the Selkirk Range, or the Sierra Nevada. On all these there are traces of glacial action on a considerable scale; but in the case of the dominant range this is not so, and, except on some of the higher peaks, where the phenomena may have a very recent origin, there is a very singular absence of such phenomena.

In such a matter I cannot quote any one better than Mr. Clarence King. He writes:

"In the field of the United States Cordilleras, we have so far failed to find any evidence whatever of a southward-moving continental ice-mass. As far north as the Upper Columbia, and southward to the Mexican boundary, there is neither any boulder clay nor scorings indicative of a southward-moving ice-mass. On the contrary, the great areas of Quaternary material are evidently subaerial, not subglacial. The rocks outside the limit of local mountain glaciers show no traces either of the rounding, scoring, or polishing which are so conspicuously preserved in the regions overridden by the northern glacier. Everything confirms the generalization of Whitney as to the absence of general glaciation. . . . . Not more than a thirtieth part of the entire surface of the fortieth parallel area was ever covered by glacial ice. . . . . Whatever the greater causes may have been, the Cordilleran surface south of Washington Territory was free from an ice-sheet, and the only ice-masses were small areas of local glaciers which did not cover two per cent. of the mountain country."

Whitney also tells us that in the interior parts of the Cordillera the ancient glaciers usually extended down to about 7000 or 8000 feet above the sea (United States Geol. Expl. of the 40th Parallel, pp. 459–461 and 464).

In Dr. Wright's recently published "Ice Age in North America," we read:

"According to Whitney there are no signs of ancient glaciers in Western Nevada, though some of the mountains rise to a height of 10,000 feet. . . . . In Colorado there are evidences of ancient glaciers *only above the* 10,000 *foot line*. . . . . The most southern point at which signs of local glaciers in the Rocky Mountains have been noted is near the summits of the San Juan Range, in South-Western Colorado. Here a surface of about 25 square miles, extending *from an elevation of* 12,000 *feet down to* 8000 *feet*, shows every sign of the former presence of moving ice. Northward of Utah and Colorado the signs of former glaciation are of the same local character; that is, glaciers everywhere radiated from the higher mountain masses, and extended *a short distance* down the cañons and valleys. . . . . The glaciers of the Sierra Nevada and Cascade Range in California, Oregon and Washington Territory were on a much grander scale than those in the Rocky Mountains" (*op. cit.* pp. 148, 149).

Professor George Dawson, in criticizing some of Prof. Whitney's views, says:

"The general result arrived at in the areas of Whitney's and

King's surveys is that comparatively only a very small portion of the highest ranges of mountains has ever been covered with glaciers, and that there has never been in this region anything like a northern drift period or a transportation of material in any given direction independent of the present topographical features of the country" ("Nature," 1881, p. 290).

Again, Mr. G. K. Gilbert, in his report on the geology of Nevada, Utah and Arizona, says:

"About White's Peak in the Schell Range, Nevada, are the terminal moraines of five or six glaciers that descended to 8000 feet altitude in lat. 39° 15′. At about the same altitude and in lat. 39° are moraines and an Alpine lake upon the flanks of Wheeler's Peak, of the Snake Range of Nevada. Old Baldy Peak (N. lat. 38° 18′), near Beaver, Utah, overlooks two terminal moraines, one of which contains a lakelet at an altitude of about 9000 feet. No traces were seen of a general glaciation such as the Northern States experienced, and the cumulative negative evidence is of such weight that Mr. Gilbert is of opinion that the glaciers of the region referred to were confined to the higher mountain ridges" ("Nature," vol. xii. p. 299).

I will quote one more witness, and he the most important, because his remarks refer to the northern prolongation of the Rocky Mountains in latitudes where we should expect to see glacial phenomena on a very wide scale.

Professor George Dawson, the distinguished son of a distinguished father, has recently mapped out in detail the district threaded by the more northern parts of the Rocky Mountains, and what do we find on his map? Why, that while on the west of the chain the erratics, which were once shed by the Cascade Range, come almost up to the Rocky Mountains on the one hand, and on the east the drift, which has everywhere spread so far from Labrador and its neighbourhood, has similarly travelled right up to the flanks of the Cordillera, not an arrow or a mark is found on the map to show that the Rockies themselves threw off any erratics of their own, or that the great masses of ice which (one must suppose) covered them in the Glacial age, if they were then existing, formed any barrier to the spread of drift on either side of them. Assuredly the fact is a very extraordinary one.

North America presents to us the most gigantic traces of ice-action to be found anywhere. Nowhere else are the polished and striated surfaces so widespread, and the boulders and wreckage of ice-action so conspicuous. East and west of the Rocky Mountains the evidence is the same. How comes it, then, that the highest ground of all, which would naturally be looked upon as the main reservoir of the ice, should be so free from its marks, and should be so sharply contrasted with the mountains of Scandinavia, with the Alps, with the Cascade Range, and with the gathering ground of the Laurentian glacier? To my mind there is only one possible explanation of the facts here mentioned, namely, that the great American Cordillera, both in North and South America, is not only, as Elie de Beaumont affirmed, one of the newest mountain ranges in the world, but that it only dates in its main features from that period of cataclysmic revolution in physical geography which closed the Mammoth age, and that it was not existing at the time of the so-called Glacial period.

This position may be supported, as similar evidence can be supported in the case of the Urals and other ranges. In the first place, it is a curious proof that the Rocky Mountains are very recent, that they do not constitute a real zoological boundary. On this subject I cannot quote a better authority than Mr. Murray, who, in his Geographical Distribution of Mammals, p. 313, says, "We should expect the Rocky Mountain range to form the chief longitudinal line of separation, but, as already said, it only separates species in a minor degree. The actual mountain barrier appears to be the Cascade Range on the west side of the Rocky Mountains, separating Oregon and California from the rest of North America; and the dividing limit between the two other regions seems to be the Nebraska country, on which lie the Mauvaises Terres and Nebraska, and Niobrara beds on this side of the Rocky Mountains—the line of separation, in fact, being marked by the site of the ancient Tertiary sea in which these beds had been deposited."

In the first place, it is a remarkable fact that the remains of the South American Mastodon of precisely the same species should have been found on both sides of the Cordillera of the Andes. It is incredible that an animal of the type of the Mastodon, which, as we know, fed on trees, should have traversed the high range over which the Alpaca and Vicuna can hardly pass. In North America the same fact presents itself, and we have remains of the Mastodon occurring in California and in Oregon, on the western side of the Rocky Mountains, as on the plains east of that range. This seems to me to be very strong evidence that the Cordillera was not existing in the Mammoth age to act as a zoological frontier.

Again, it was long ago observed by Humboldt that remains of the same animal occur on the high plateau of Quito and elsewhere at a tremendous elevation in South America, while the Mammoth left its bones on the high plateau of Mexico, thus offering a parallel to the remains from Hiundes in Tibet.

I will quote one or two instances in support of this contention. *Inter alia*, Humboldt discovered a large number of Mastodon remains in the so-called Giants' Camp at Santa Fé de Bogota, in Peru, at a height of 1300 toises (*i.e.* 2600 mètres) above the sea (*id.* p. 264). He found similar remains near the volcano of Imbaburra in the kingdom of Quito, also in Peru, at a height of 1200 toises (*i.e.* 2400 mètres) (*id.* p. 266). Others again at Chiquitos, near Santa Cruz de la Sierra, in 18° S. lat. and almost in the centre of South America. On the west of the Cordillera J. de Jussieu reports a great deposit of these bones in the valley of Tarifa at a distance of more than 130 leagues from the sea, and 200 from Potosi, while Humboldt sent one to Cuvier from Conception de Chili in 37° S. lat. (*id.* p. 267). Darwin also found remains of the Mastodon at Santa Fé, and speaks of their occurring up to the snow-line.

These facts are assuredly remarkable, and it is not strange, therefore, to find that Humboldt, after remarking how the bones of the great pachyderms scattered in the auriferous gravels on the flanks of the Urals prove the very recent origin of that chain, should go on to say: "Cette même conclusion de soulevement s'applique aux Andes, ou, dans les deux hemisphères sur les plateaux du Mexique, de Cundinamaska (near Bogota), de Quito et du Chili, on decouvre des ossemens fossiles de mastodontes à 1200 et 1500 toises de hauteur" (Geol. et Clim. Asiatique, pp. 381, 382, *note*).

See also his Relat. Hist. vol. i. pp. 386, 414, 429; vol. iii. p. 579.

Turning to another part, one curious feature of the Rocky Mountains pointing to their cataclysmic origin is the sudden and abrupt way in which they rise out of the adjoining plains. Thus Mr. Ball says: "The Rocky Mountain rises up from the midst as it were of a horizontal sea of red sandstone; as if some tremendous force had driven it upwards, like an island forced up from the depths of the ocean" (Silliman's Journal, vol. xxv. p. 35).

Reclus says: "La chaine des Montagnes Rocheuses ne projette pas de rameaux proprement dit dans les plaines orientales. Des terrains onduleux viennent se heurter au pied des Monts comme des vagues qui frappent les rocs d'un promontoire: la transition est brusque entre les escarpements et les plaines" (Nouvelle Geog. Univ. vol. xv.).

This is assuredly only consistent with this chain having been elevated by a local paroxysmic movement, and not by a slow general alteration of the level of the continent.

Another feature in which America and Asia resemble one another, and which points to a recent elevation of the land, is the fact of the existence of a number of small salt lakes which attest to wide areas of water having been recently drained. Thus, Mr. J. K. Gilbert, in his Geological Report, says that the level of what is now "Great Salt Lake must at one time have been much higher, and its area must have been much greater than it is at present. Former levels are marked by a series of conspicuous shore-lines carved on the adjacent mountain slopes to a height of more than 900 feet. When the waters rose to the uppermost beach, they must have covered an area of about 18,000 square miles, eleven times that of the present lake, and a trifle less than that of Lake Huron. The average depth was 450 feet, and the volume of water nearly 400 times greater than now." Mr. Gilbert believes "that the flooding of the Great Salt Lake Valley was contemporary with the general glaciation of the northern portion of North America, and with the formation of the numerous local glaciers of the western mountain systems, he considers it a phenomenon of the Glacial Epoch" ("Nature," vol. xii. p. 299).

Reclus describes the American salt wastes in his usual graphic manner. Thus, speaking of the desert of Utah, he says, "It is an immense surface of clay, dotted over with thin tufts of Artemisia; in certain places, however, it exhibits no trace of vegetation, and resembles a causeway of concrete, intersected by innummerable clefts, forming nearly regular polygons. In the midst of these solitudes no rivulet flows, and no water spring gushes forth; only after journeying for many a long hour the traveller sometimes comes upon some field of crystallized salt, a white expanse on which the clouds and blue sky are reflected as on the surface of a lake. . . . . The solitudes of the Andes most resembling the desert regions of the old world and of the United States are the elongated plateaux, which rise one above another between the sea and the principal chain of the Andes, in southern Peru, and on the frontiers of Bolivia and Chili; such as the Pampas of Islay and Tamarugal, and the desert of Atacama. The Pampa of Tamarugal has a mean altitude of from 2900 to 3900 feet. It is a plain nearly covered with beds of salt, or *salares*, which are worked like rock-quarries. The strata of salt are so thick, and rain is so rare upon the plateau, that the houses of the village of Noria, which are inhabited by the workmen, are entirely constructed of blocks of salt. Some deserts situated to the east of the Tamarugal, on more elevated plateaux, contain a still larger quantity of salt.

The Pampa of Sal, which is overlooked by the volcano of Isluga, has a mean altitude of not less than 13,800 feet, and its whole extent, which is 125 miles long, and from 9 to 24 miles wide, is perfectly white. The depth of salt deposited upon this plateau varies from 5 to 16 inches, according to the undulations of the ground."

"Whence do these enormous masses of salt proceed? Doubtless from the sea or ancient lakes which formerly covered these countries, and have been gradually emptied by the rising of the soil" (Reclus, "The Earth," pp. 107–108, and 110–111).

We can hardly separate the drainage of these seas from the upheaval which uplifted great collections of bones of the Mastodon to a level close to the snow-line, and quite outside the range of the soft-wooded trees on which they fed. The Salt-licks of Ohio actually contain great masses of Mastodon and other bones.

If we cross the Cordillera, both in North and South America, from west to east, we have another and equally difficult problem to solve, namely, to account for the vast and continuous beds of unstratified loam which, whether we call it Loess or Pampas mud, has the same structure, and which no ingenuity can mistake for a deposit which has been thrown down by water in a gradual way, or been accumulated at all in a gradual way, since it not only has no signs of stratification, except in very local circumstances, but overspreads whole continents with its mantle, irrespective of the drainage or the contour of the country, and which seems unmistakeably to prove the operation of some rapid and cataclysmic cause.

In regard to South America some of the most distinguished geologists, such as D'Orbigny, Brongniart, Elie de Beaumont, etc., have not scrupled to explain it as a consequence of the sudden or very rapid upheaval of the Andes. D'Orbigny, who is much the most distinguished geologist who has written on South America, which he explored so diligently, and upon which he published a most magnificent work, is very emphatic on the subject, and I must quote some passages from his too little consulted masterpiece.

The Pampas deposit, he tells us, covers an area of 23,750 square leagues, and rises gradually from the sea-level to a hundred mètres or more. It also fills small elevated valleys as at Tarija, at Cochabamba, 2575 mètres above the sea, and all the Bolivian plateau at the mean height of 4000 mètres; so that it occurs at all heights from the sea to the summit of the Cordilleras. It consists of a homogeneous reddish unstratified loam. It is the same at Chiquitos and Moxos, while on the Rio Piray it is somewhat mixed with clay, and is the same on the high plateaux as it is on the Pampas, and only contains Mammals' bones. It covers, in fact, the surface of nearly all South America, and is the result of one general cause (D'Orbigny, vol. iii. pt. 3, pp. 250, 251). It covers deposits of all ages—Silurian, Devonian, Carboniferous, Triassic and Trachytic (*id.* p. 253). If, as Darwin argued, this deposit was of fluvatile or estuarine origin, how, says D'Orbigny, can we explain its presence both on the plains and the high plateaux? This makes it clear that its cause was not a local but a general one (*id.* p. 255).

Another fact which points the same moral is the absence of stratification in these loamy beds. In certain places it is harder or more or less sandy; but these parts, far from being separated from the rest by horizontal lines, which always show themselves in beds deposited slowly from water, form one mass with indistinct zones which are very transient. In one word, it may be said that the Pampas mud was deposited in a very short time and was the result of a great terrestrial commotion (d'Orbigny, vol. iii. pt. 3, p. 73).

Elsewhere he explains what, in his view, was the nature of this commotion. He tells us how great dislocations took place in the bed of the ocean to the west of the American continent. This dislocation was coincident with the sudden or rapid upheaval of the Andes over a length of 50 degrees or 1250 leagues. This upheaval caused the sudden movement of the sea, which invaded all at once the continent, carried off and overwhelmed the Mastodons which inhabited the eastern flanks of the Bolivian Cordillera, the Megatheriums, Megalonyxes, and the multitude of animals daily being discovered in the caverns and the fissures of the mountains of Brazil—all the species, in fact, which are extinct. It was then, perhaps, that, mixed with the earth, the animals were tumultuously deposited in the lower parts of the Tertiary basin of the Pampas, and thus formed the immense deposit of Pampas mud (*op. cit.* vol. iii. pt. 3, p. 82).

Again he says: "My final conclusion from the geological facts I observed in America is, that there was a perfect coincidence between the upheaval of the Cordilleras, the destruction of the great race of animals, and the great deposit of Pampas mud. Thus these three questions of immense importance for American geology and for the chronological history of faunæ, may be explained by one cause, namely, the upheaval of the Cordilleras, to which we may, perhaps, attribute the analogous phenomena of which Europe has been the theatre" (*id.* vol. iii. pt. 3, pp. 85, 86).

Elsewhere again he points to other facts which prove more directly the coincidence in time of the rise of the Cordilleras and the deposit of the Pampas mud by the waters as the result of this elevation are without doubt the numerous depressions and denudations which cut into the soil from east to west, and the dispersion of porphyry boulders over all the Tertiary deposits of Patagonia. If these denudations had been subsequent to the deposit of the Pampas mud, it is evident that the porphyritic boulders with which the ground is covered over round the circumference of the Pampas would also have covered the Pampas deposit, whereas they cease just where the Pampas mud begins, as Darwin showed when he says they are found from the Straits of Magellan to the Rio Colorado. We may thus look upon the elevation of the Cordilleras as the cause which at the same time drove the water from West to East with sufficient violence to denude the Tertiary soil in the direction of the slope, and to sweep from the Andes the porphyry boulders which cover all Patagonia, and we may see in the same fact the reason why the vegetable soil, etc., was swept from all the Tertiary strata of Patagonia to be deposited in the great reservoir of Pampas mud.

I hold that the waters which deposited the Pampas mud were salt, because all the clay deposits of the Upper Andes containing bones are saline. It is so also with the Pampas mud, which shows efflorescence at different points. But the best proof is the existence of salt lakes dating from this period at the summit of the Cordilleras, and in all the depressions caused by water in the plains of Patagonia, and this perhaps accounts for the salt springs occurring in various places" (D'Orbigny, vol. iii. part 3, p. 82, etc.).

These views were shared by other inquirers. Thus in a report to the French Academy on the discoveries made by Lund in Brazil, we find the reporters, Brongniart, Dufrenoy, and Elie de Beaumont, saying, "The deposit in Brazil only differs from that of the Pampas by the presence of quartz pebbles, probably derived from subjacent beds; there it is from 3 to 16 mètres thick, and extends up the flanks of the mountains to a height of 2000 mètres." Mr. Lund attributes the red loam of Brazil to a great irruption of waters which covered all this part of the earth, and put an end to the existence of living animals. "Whatever modifications this hypothesis is destined eventually to suffer, it seems to us evident," say the learned reporters, "that the extension of the Pampas mud over the mountains of Brazil upsets the theory that this mud was deposited tranquilly in the estuary of a great river, and this extension seems very probable, since the Brazilian mountains are not the only ones where it occurs." . . . . The area covered by the Pampas mud is equal to that of France, and the deposit which contains Megatherium, Megalonyx, Hoplophorus, and Mastodon, on the Parana, is 200 myriamètres from Minas Geraes, where Lund found the same animals, proving that the cause of their deposition operated on a great scale over the continent of America, and that we must invoke, if we are to explain it, some general and widespread cause.

I have not pretended in this short paper to do more than collect a few salient facts, which might be greatly multiplied. They seem to establish that the American Cordillera, like the Highlands of Eastern Asia, form a very new feature in the physical history of the world. They show that their upheaval dates very largely from post-Tertiary times, that it was very rapid, if not sudden, and that it caused a widespread diluvian movement, to which we must attribute the destruction of a large part of the Pleistocene fauna, and the spreading of the great mantles of unstratified loam in the Pampas of South America, and the Loess districts of the North.

III.—ON THE BRITISH EARTHQUAKES OF 1890, WITH THE EXCEPTION OF THOSE FELT IN THE NEIGHBOURHOOD OF INVERNESS.

By CHARLES DAVISON, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

THE most remarkable earthquakes of the year 1890 were those felt in the district round Inverness between November 15 and December 14. These have been described in a separate paper.[1] The remaining earthquakes were of comparatively slight intensity. Two or three were felt during the night of June 25–26 within a very small area to the north-east of Leeds, and one at least in Kintyre on July 24. Several slight shocks at Invergarry and Feddan, in Inverness-shire, complete the list so far as known to me, with the exception of a doubtful shock at Tulliallan in Perthshire on January 6.

It is hardly necessary to do more than refer here to the two supposed earthquakes felt on January 7 at and near Chelmsford. In a letter to "Nature,"[2] I have given the evidence in full; and it appears to me sufficient to show that they were merely the reports of one of the great Woolwich guns. The reasons of this conclusion are, briefly: (1) exactly at the times given (12h. 30m. and 13h. 25m.), a 110-ton gun, the heaviest in the service, was fired at Woolwich; (2) the wind was S.W. over nearly the whole of England on the day mentioned, and all the places from which I have received records are close to a line passing in a north-easterly direction from Woolwich; and (3) the descriptions of the shocks show that they were due to impulses transmitted through the air rather than through the earth.

YORKSHIRE EARTHQUAKES: JUNE 25–26.

a. June 25, about 22h. 30m.; Intensity, IV.; Epicentrum, about half a mile N.E. of Walton.
b. June 26, about 1h.

First Shock: *June* 25, *about* 22h. 30m.—I have received records of this shock from 19 places, which, with two exceptions, lie within an area about 11½ miles long and 7 miles broad; the direction of its longer axis being about W. 17° N. and E. 17° S. The boundary-line of this area corresponds to an isoseismal of intensity IV. or nearly so; it contains a little more than 60 square miles.

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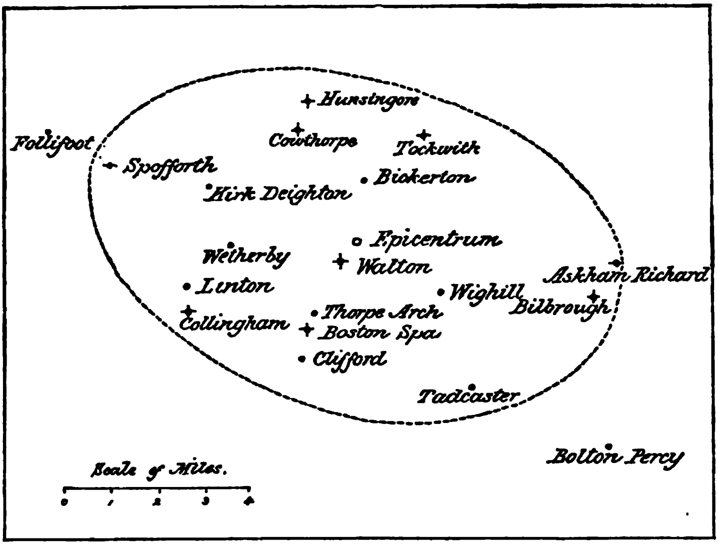
[1] Read before the Geol. Soc. on June 24.
[2] "Nature" (Feb. 20, 1890), vol. 41, p. 369.

Throughout the disturbed area, the shock seems to have consisted of a single vibration; no tremulous motion being noticed either before or after. At Boston Spa, it is said to have resembled "an explosion, or the sudden and loud banging of a subterranean door." At Walton, a village close to the epicentrum, the movement was lateral only, no vertical motion being perceptible.



Yorkshire Earthquake, June 25, 1890. (22h. 30m.)

Estimates of the duration are variable, and probably include that of the accompanying sound in one or two cases. At Collingham, the shock seemed to be instantaneous. It is stated to have lasted a second or two at Boston Spa, two seconds at Hunsingore, about three seconds at Walton, and about ten seconds at Tockwith.

The intensity was IV. at Askham Richard, Bilbrough, Boston Spa, Cowthorpe, Spofforth, Tockwith, and Walton; and III. at Bolton Percy.

Sounds were heard accompanying the shock at eight places at least; from eight others no record is given on this point; at three places, Askham Richard, Bolton Percy, and Spofforth, it is expressly stated that no sound was heard. The sound-area was, therefore, somewhat less extensive than the disturbed area.

The epicentrum is about half a mile N.E. of the village of Walton, and 13 miles N.E. of Leeds.

Second Shock: *June* 25, *about* 1 h.—This shock was felt by several persons at Boston Spa, but I have not been able to obtain any detailed observations.

On the same day, at about 4h., a third shock is said to have been felt, at Wetherby; but, in the absence of any further information, its occurrence must be regarded as doubtful.

Origin of the Shocks.—In the immediate neighbourhood of the epicentrum, there appears to be no fault with which these earthquakes may be connected: at any rate, none is marked upon the Survey map. The evidence given above, slight as it is, seems to me also rather to oppose than to favour the view that they were fault-formed shocks.

Somewhat similar shocks, though disturbing smaller areas, are of frequent occurrence at, and in the neighbourhood of, Sunderland. These have been studied and discussed by Prof. G. A. Lebour in an admirable paper "On the Breccia-gashes of the Durham Coast, etc."[1] The magnesian limestone at Sunderland is about 400 feet thick. It contains numerous caverns, many of them naturally formed, some probably artificial owing to the withdrawal of water by the local water company. Fragments of rock must frequently fall from the roofs of these caverns, and it is to the concussions produced by them that Prof. Lebour, with very good reason I believe, attributes the Sunderland shocks. That such falls have frequently taken place in former times is obvious from the constitution of the numerous "breccia-gashes" which may be seen along the coast of Durham. That they are probably continuing at the present time is shown by evidence which has been obtained since the publication of Prof. Lebour's papers. The Sunderland shocks are especially numerous at certain parts along the banks of the Hendon Burn, a small stream about a mile south of the River Wear. The Sunderland and Ryhope Road crosses the stream nearly at right angles, and, for a distance of about 400 yards on the north side, and about 150 yards on the south side of the stream, it has been found that the road has recently subsided. The Ordnance Survey levelling of the road was carried out in 1857, and in 1887 the levelling was repeated by a well-qualified surveyor at the instance of Mr. T. W. Backhouse, of Sunderland. The average subsidence of the road over the distance mentioned was found to be 1 foot 10 inches in the thirty years; at the stream itself the subsidence was 2 feet 4 inches. A large part of this subsidence seems to have taken place towards the end of this period; for, in four years, 1883–87, Mr. Backhouse found by observations of a distant chimney, that his observatory, which is close to the Ryhope road, had been lowered by 1 foot 4 inches, and it is worthy of notice that just about this time the slight shocks became especially frequent.

The part of the disturbed area surrounding the epicentrum of the first of the Yorkshire shocks consists also of magnesian limestone, though its thickness is less than at Sunderland.[2] The depth of the seismic focus must have been very slight. This is shown by—(1) the smallness of the disturbed area considering the intensity of the shock; and (2) the horizontal direction of the motion at Walton, a village only about half a mile from the epicentrum. Bearing in mind also the nature of the disturbances, it seems to me therefore very probable that the Yorkshire earthquakes were due to the falling of masses of rock in caverns of the magnesian limestone.

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[1] Trans. of the N. of Engl. Inst. of Mining Eng. (Newcastle-upon-Tyne), vol. 33, 1884, pp. 165–174. See also a paper by the same author, "On Some Recent Earthquakes on the Durham Coast and their probable cause," Geol. Mag. (1885), Dec. 3, Vol. II. pp. 513-515.

[2] In the neighbourhood of Tadcaster, the thickness of the Permian formation (Upper Marls to Lower Magnesian Limestone, inclusive) is 300 feet (Mem. Geol. Surv., Explanation of Quarter-sheet 93 S.W.).

Authorities.—A short account of the shock is given in the "Leeds Mercury" for June 27. But for most of the observations on which the above description is founded, I am indebted to the kindness of the following correspondents: Askham Richard, Mr. T. B. N. Miles; Bilbrough, Miss Metcalfe; Bolton Percy, the Right Rev. the Lord Bishop of Beverley; Collingham, Rev. G. L. Beckwith; Cowthorpe, Rev. S. H. Gaisford; Hunsingore, Rev. J. J. D. Dent; Spofforth, Mr. R. T. Vyner; Tockwith, Mr. F. M. Clarkson; Walton, Mr. E. B. Waite, F.L.S. The details with reference to the subsidence of the Sunderland and Ryhope Road are taken from a letter by Mr. Backhouse in the "Sunderland Daily Echo" for Dec. 6, 1887.

KINTYRE EARTHQUAKE: JULY 24.

Time of occurrence, 11h. 37m.; Intensity, V.

I did not hear of this earthquake until some months after its occurrence. Partly on this account and partly from the difficulty of obtaining information in a district so thinly peopled, I can give but little beyond a slight description. I regret this the more, as it would have been interesting to have traced its relations with the earthquake felt in the same district on July 15, 1889.

Most of the places from which I have received records are indicated on the map of the earthquake of 1889.[1] These places are Clachan, Glen Saddell, Gigha, Kilberry, Tayinloan and Whitehouse. At Clachan and Tarbert the shock was accompanied by a rumbling noise. Throughout the island of Gigha, to the west of Kintyre, a rumbling noise was heard, but the shock itself was not perceived. Neither shock nor sound was noticed at Bellochantuy, nor at Lochranza in the island of Arran.

With evidence so slight, it is not possible to determine the outline of the disturbed area. It cannot have differed much from that of the year before; towards the north and south its limits may have been about the same; but it did not extend so far towards the east. Its epicentrum, though probably not very distant from the village of Clachan, must therefore lie somewhat to the west of that of the earthquake of 1889.

With regard to the nature of the shock, I know very little. At Clachan, it began with a series of tremors "so sharp, short and quick as not to be easily counted." These increased in intensity until, at the end of twenty seconds, "a vibration was felt like what would be caused by a heavy stone falling from a very great height."

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[1] See page 366 of this volume. Tayinloan is about one mile N. of Killean; Whitehouse, 7 miles E. 15° S. of Kilberry; Bellochantuy, 7½ miles S. 10° W. of Killean.

After this prominent vibration, or "blow," the tremulous motion was again felt, and lasted for five seconds. During the whole time that the tremors lasted, a sound was heard "resembling the noise of stones falling down a chimney," loudest at the moment when the "blow" was felt, a dull "thud" being then heard "as of a suppressed explosion."

The intensity was V. at Clachan, and at Tarbert not less than IV.

About noon on the same day, a second shock was felt at Clachan; but. so far as I know, by one observer only.

Authorities.—For the information on which the above short account is furnished I have pleasure in thanking: Bellochantuy, Miss M. Currie; Clachan, Rev. J. Cameron, Mr. A. McLellan; Glen Saddell, Mr. J. McLeod, of Saddell; Gigha, Mr. R. A. Cavana, Rev. J. F. McKenzie; Lochranza, Rev. J. Johnstone; Tarbert, Mr. J. Brown.

EARTHQUAKES AT INVERGARRY AND FEDDAN.

The earthquakes at these two places[1] are interesting owing to their possible connexion with the great fault which follows approximately the course of the Caledonian Canal. Invergarry lies about a mile N.W. of the centre of Loch Oich, and Feddan about three miles N.W. of the centre of Loch Lochy. For the following lists I am indebted to the kindness of Mr. John Grant, of Invergarry, and Mr. Murdoch Matheson, of Feddan, both of whom are doing most valuable work in recording the occurrence of earthquake-shocks.

Invergarry.

Jan. 5. 2h. 30m., a shock of intensity IV.
,, 16h. 35m.
,, 16h. 40m.
,, 16h. 47m., like a heavy carriage passing.
Jan. 19. 16h. 55m., the same.
Mar. 15. 8h. 45m., resembled the noise of a heavy train.
May 29. 16h. 45m., like a heavy carriage passing.
Aug. 8. 15h. 35m., the same.
Nov. 16. 20h. 30m., like a passing train. Though occurring at the same time as the fourth shock of the Inverness series, this must have been a distinct shock.
Dec. 1. 10h. 10m., a slight shock.

Feddan.

Nov. 19. 1h. 33m., a very slight shock, preceded by a low rumbling noise.
Dec. 26. 18h. 10m., a loud noise resembling thunder heard, followed by a trembling motion, lasting fully two minutes. Almost immediately afterwards, another and louder sound was heard, without any accompanying tremor.

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[1] At both places, the shocks are recorded by only one observer, and should therefore, strictly, be regarded as doubtful shocks; but I have placed them under a separate heading, as both observers have for several years diligently recorded the occurrence of every shock felt by them.

DOUBTFUL EARTHQUAKE.

Jan. 6, between 1h. and 2h., Tulliallan (south of Perthshire).

The following account is taken from a paragraph in the "Perthshire Advertiser" for Jan. 8. "Between one and two o'clock .... what is believed to have been an earthquake shock was distinctly felt in the parish of Tulliallan. The night was extremely stormy, with thunder and heavy sleet showers. But readily distinguishable from the sound either of the wind or of the thunder there arose a roaring noise like that of an express train passing at full speed, accompanied by a trembling sensation of the ground, such as Londoners who dwell near the Underground Railway are accustomed to. The noise seemed to increase in intensity as it approached, and then died away again in the distance, just as that of a passing train would have done. There is no railway within several miles."

This is the only account I have been able to obtain. From the description, it is obvious that the shock closely resembled that of an earthquake, but, considering the circumstances of its occurrence, the evidence is not sufficient in itself to establish its seismic origin.

IV.—LOWER GREENSAND AND PURBECKS IN THE VALE OF WARDOUR, WILTS.

By the Rev. P. B. BRODIE, M.A., F.G.S.

IN the GEOLOGICAL MAGAZINE for July last the Rev. W. Andrews and Mr. Jukes-Browne gave an account of Lower Cretaceous strata in the Vale of Wardour. I can bear testimony to the correctness of this statement. Many years ago, when geologizing in the vale chiefly among the Purbecks, I found many portions of ironstone and hard ferruginous sandstone, in the fields and by the roadside both at Dinton, Teffont and especially at Chilmark, containing casts of *Cyrena, Turritella*, and a part of a dermal scute of a Saurian, which I believe belong to the Lower Greensand, but I never saw it *in situ*, and it seems to have been greatly denuded. A few years ago, after an absence of nearly fifty years, I paid another visit to some of my old haunts in this beautiful district, in company with Mr. Andrews, who was anxious to find out the exact spot where I obtained insects, fish and *Archæoniscus*; but after a careful search no trace of the old quarry could be seen, and the place was filled up and overgrown with bushes. In no other locality in the Vale has a similar limestone been found, though *Archæoniscus* and a few remains of insects occur lower down in the Middle Purbecks at the lime quarry above Teffont Rectory, where Mr. Andrews has obtained several new and interesting fish,[1] plants, and other organisms. At Dinton the insects were fairly abundant, and *Archæoniscus* especially so. It seems probable that the insect limestone below the Archæoniscus bed there is of limited extent, though if pits were opened at the same spot more of the limestone would be found.

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[1] Among these fish is *Coccolepis Andrewsii*, A. S. Woodw., which is allied to *Palæoniscus*, and is now in the Jermyn Street Museum. Mr. Smith Woodward lately showed me another remarkable small fish sent to him by Mr. Andrews from Teffont, which the former will shortly figure and describe. These, added to the others long ago figured and described from Dinton, make a most interesting list of new forms from the Wiltshire Purbecks. The other genera from Teffont include *Pleuropholis, Microdon*, showing the teeth *in sitú*, and *Lepidotus minor*.

The cutting in the railway close by exposed the Isopod limestone, but no trace of the Insect bed was seen, as the excavation at this spot was not deep enough to reach it. At Chicksgrove, in the large quarry then opened near Tisbury, at the base of the Purbecks, I only obtained one elytron of a beetle, but some *Archæoniscus* very much larger than those at Dinton and Teffont. This may be a new species, but has not been figured or described. It is twice as large as the specimen figured in Fossil Insects, pl. i. fig. 7. Owing to the rough nature of the matrix, probably 'the cap' of the Isle of Portland, these are not so well preserved as those from Dinton and Teffont. This Isopod Crustacean evidently ranged from the base of the Lower Purbecks at Chicksgrove, through the lower part of the Middle Purbecks at Teffont to the upper division at Dinton. In one specimen of *Archæoniscus* from Durlstone Bay, Dorset, the Isopod is lying on its back, showing all the legs folded together under the abdomen,—the only example I ever obtained in this position. The recent discovery by Messrs. Andrews and Browne of Upper Purbecks in the Vale of Wardour, hitherto supposed to be absent, is of much interest to geologists, especially to those who, like myself, have long studied these beds.

V.—NOTE ON AN UNDESCRIBED AREA OF LOWER GREENSAND OR VECTIAN IN DORSET.

By A. J. JUKES-BROWNE, B.A., F.G.S.

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UNTIL recently no outcrop of the Vectian or Lower Greensand was known to occur between Lulworth on the coast of Dorset and the neighbourhood of Devizes in Wiltshire. It was supposed that, with the exception of a small area of Wealden in the Vale of Wardour, the whole of the Lower Cretaceous Series in Dorset and South Wilts was concealed and buried beneath the overlapping Upper Cretaceous strata. A recent examination of this district however has revealed two areas where the Vectian sands emerge from beneath the Gault. One of these has already been indicated in the pages of the GEOLOGICAL MAGAZINE;[1] the other is the subject of the present communication.

Reference to the Geological Survey Map, Sheet 15 will show that the Gault was supposed to thin out and disappear near Shaftesbury so as to allow the Upper Greensand to rest directly on the Kimeridge Clay. This proves to be a mistake; the Gault is continuous below the Upper Greensand into and beyond the valley of the Stour. Moreover, two miles south of Shaftesbury and a little east of the hamlet of Twyford a tract of sand emerges from beneath the Gault and forms a terrace which for a little distance has an escarpment of its own. Near Bedchester this terrace, or dip-slope, is nearly half a mile wide; thence it can be traced southward to Farrington, where it bends westward, still making a prominent feature, and passing above Fontmell Parva it runs into a hollow by Child Okeford on the eastern side of the Stour valley.

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[1] The Lower Cretaceous Series in the Vale of Wardour, by A. J. Jukes-Browne and W. R. Andrews, GEOL. MAG. for July, 1891, p. 292.

The length of this tract is between four and five miles, but only two good exposures have yet been found along it. These are, however, sufficient to give some interesting details of the beds which constitute it. One of them is a road-cutting by Piper's Mill, between Bedchester and Fontmell Magna, and to expose this more clearly two narrow trenches were cut down the bank. By this means the following beds were observed:—

	Feet.
Brown loamy soil	1 to 2
Mottled brown and grey clay containing in the lower part pebbles of vein quartz and lydianite as large as beans (? base of Gault).	2
Greenish-brown sand with clay mottlings	2
Soft purple brown clay (1 foot) passing into dark green sandy clay, with laminæ of purple clay and patches of greenish-brown sand, and finally into mottled sand, brown, yellow, and green	5
Purple black laminated clay and sand	1
Greenish-black clay full of glauconite grains	2½
Hard brown sandstone cemented with oxide of iron ...	0½
Rather coarse yellowish-brown sand...	1½
Fine soft greenish-grey sand, seen for	2
about	18

The other exposure in a sand-pit east of Bedchester seems to begin where this leaves off. It shows remnants of the ferruginous sandstone underlain by greenish-brown sand with two layers of coarse yellowish sand and then 6 feet of fine greenish brown sand, below which is some 5 or 6 feet of dark-green glauconitic sand. This last is well exposed along the gully of the watercourse that runs by this spot toward Piper's Mill.

From these particulars it appears that the total thickness of the sands near Bedchester is at least 30 feet, and probably between 30 and 40 feet. There are some thin layers of coarse quartz sand in the upper part, but the greater part is fine sand consisting of small even-sized grains of quartz (not much rounded), and grains of dark-green glauconite, many of which are smaller than the quartz-grains.

The occurrence of the dark glauconitic mud or clay is particularly interesting, both as showing that we are not here dealing with a littoral or very shallow water deposit, and also because a similar bed, consisting of black clay in the upper part and dark greensand below, was found in the Vectian of the Vale of Wardour. The bed at Piper's Mill appears to consist of an intimate mixture of dark purple-grey clay and very fine glauconitic sand, chiefly glauconite, with some minute grains of quartz and mica.

It may be mentioned that a boring made at Fontmell Brewery a few years ago has been carried through the Gault into sand similar to that above described, and a good supply of water was obtained which rises above the surface of the ground.

It is also worthy of note that this emergent tract of Vectian sand is the most westerly exposure yet known, with the exception of that near Lulworth Cove, which, however, is of much smaller size, compared with the tract above mentioned. It happens too that this tract, and that near Lulworth, are almost exactly on the same line of longitude.

Considering its position, the amount of glauconite present, the fineness of the sand, and the existence of interstratified clay are remarkable facts, suggesting that the deposit was formed at some distance from a shore-line. Comparison with the exposures near Devizes and Seend certainly suggests that the latter were formed in much shallower water and much nearer a coast-line.

VI.—ON A SPECIMEN OF *WALDHEIMIA PERFORATA* (PIETTE), SHOWING ORIGINAL COLOUR-MARKINGS.

By EDWARD WILSON, F.G.S.,
Curator of the Bristol Museum.

THE retention of the original colour-markings amongst fossil Brachiopoda is a somewhat rare occurrence: the following striking instance therefore seems worthy of record.

It is true that Deslongchamps in the Paléontologie Française mentions the colours of a number of Jurassic Brachiopods, but in nearly all these cases the colours are spoken of as if uniformly distributed and not patterned over the shells,[1] and therefore we cannot be sure that they are original and not subsequently produced.

Of British fossil Brachiopods which show the colour-markings, *Terebratula hastata* and *Discina nitida* respectively from the Carboniferous Limestone of Longnor, Derbyshire and Hamilton, Scotland, *Terebratula intermedia* from the Cornbrash of Wollaston, and *Terebratula biplicata* from the Upper Greensand of Cambridgeshire, are examples.[2] In these cases the colour-marks are generally in the form of radial, *i.e.* vertical bands or striæ.

The specimen to which I now call attention is one belonging to the species *Waldheimia perforata*, Piette, and comes from the Lower Lias of Bitton, Gloucestershire.

The colour indications on this shell are in the form of clearly defined concentric bands of black and white of varying breadth, conforming approximately but not rigidly with the lines of growth. The bands of colour are bilaterally symmetrical, and, what is still more important as indicating that they are original, correspond in the two valves, except that as we should expect they are broader in the larger and more rapidly growing ventral valve, and show a tendency in that valve to split up into smaller rings. Commencing at the beaks we have in each valve a white circular area crossed by three nearly equidistant and narrow black rings, then a broad black band which in the ventral valve is imperfectly divided into three black rings by two narrow white streaks; then a broad white lunate area shading off into black towards the horns, and finally a broad black band which, with the exception of a slight white mottling in the ventral valve, extends without interruption to the frontal margin. What the actual colours were in the living shell it is impossible to say, but from the markings, still retained, in this solitary specimen, *Waldheimia perforata* appears to have been a decidedly handsome organism.

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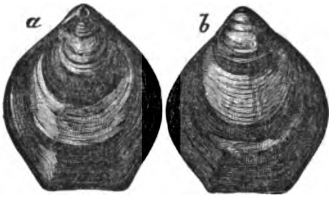
[1] The colour of *Waldheimia perforata* for example is given by this author as "brun foncé violacé."

[2] *Vide* T. Davidson, Palæont. Soc., British Fossil Brachiopoda, vols. i. ii. and iv.



Waldheimia perforata, Piette, showing original colour-markings. *a*, front view; *b*, back view. Both natural size.

The above specimen is a full-grown and typical example of the species, 23 mm. long, 20 mm. broad, and 13 mm. in its greatest antero-posterior diameter. It was found by my friend Mr. J. W. D. Marshall, of Bristol, in whose excellent collection of British Jurassic Brachiopoda it now is, at the riverside quarry, Stout's Hill, Bitton, where the species is by no means rare. The specimen was not actually found *in sitú*, but the beds from which it was undoubtedly derived are usually referred to the zone of *Ammonites Bucklandi*. From the prevalence, however, of the typical ammonite and the general character of the associated organisms here as well as at other places in the Bristol district, I am inclined to think that this fossil comes from the zone of *Ammonites angulatus*.

VII.—NOTES ON THE ALTERED CONISTON FLAGS AT SHAP.

By W. MAYNARD HUTCHINGS, Esq.

THE alteration undergone by the Coniston Flags, owing to the intrusion of the Shap granite, has been well and fully described by Messrs. Harker and Marr in their most able and interesting paper, read before the Geological Society in the spring of this year, "The Shap Granite and the Associated Igneous and Metamorphic Rocks" (Q.J.G.S. vol. xlvii. 1891).

I have worked a great deal, microscopically, on the rocks of this district, both before and since the publication of the results of Harker and Marr, and this work has enabled me in a special manner to appreciate the quality and value of their investigations in this complicated and interesting region. I was so fortunate, two summers ago as to spend some time at Shap with Mr. Marr, who most kindly assisted me to understand some of the problems involved, and pointed out to me the places where specimens of special interest could be collected.

For certain reasons I have taken much interest in the altered flags of Wasdale Beck, and have this summer paid another visit and collected a large number of fresh specimens, from which I have had sections prepared.

It may be worth while to note one or two of the results of the study of these and former sections, though all the main points as regards these rocks have been so completely dealt with in the above-mentioned paper.

There are two contact-minerals to record not previously observed here by Harker and Marr, nor by myself, viz. hornblende and garnet. The former occurs in large quantity in two of my sections several hundred yards above the falls near the hotel, but before the development of any of the "spots" in the altered flags. It is a very pale-green variety; so pale that in very thin sections its colour and dichroism are barely perceptible. I suppose that, though not quite colourless, it may be reckoned as tremolite, to which variety the hornblende of contact-slates, etc., is usually referred. The extinction-angles are mostly 16° to 18°, but sometimes higher. It occurs as good-sized irregular grains, long prismatic bits with ragged ends, and small fragments disseminated through the rock. The amount of brown mica present is very much diminished in the sections which contain hornblende.

My specimens are not sufficiently frequent to determine the points of appearance and disappearance of the hornblende along the course of the stream; but at one point a section very full of it was taken a few feet away, *laterally*, from another section which does not contain a trace of the mineral.

Harker and Marr point out that, as the strike of these beds coincides very closely with the line of exposure along the stream, we need not expect any variation in the original nature of the rocks. But they must have varied a good deal within narrow limits *across* the strike. These hornblendic specimens are different in several ways from the more normal rock, notably in the amount and size of the quartz present. Doubtless, also, they were originally calcareous bands, while most of the flags exposed in the beck were not.

Somewhat higher up the stream, and at about the same stage as the development of decided "spots," the garnet appears in great force. It is quite colourless and quite isotropic, with large amounts of included granular and microlithic material not determinable. The garnets are mostly in the form of crystals, but also as rounded and irregular grains. The largest have a diameter of $\frac{1}{200}$ inch. They are mostly pretty evenly dispersed and occur indifferently in the spots and in the surrounding mosaic, but at some parts of the slides they are aggregated into large clusters and packs.

This mineral, again, seems to be very local in its occurrence, appearing and disappearing within a distance of a few yards *along* the slide, and of a few feet *across* it.

One of my objects in taking a new series of specimens was to endeavour, if possible, to obtain more evidence as to what is the real nature of the substance, or substances, in course of formation in the comparatively clear "spots" which are so prominent a result of the alteration of these rocks. In this I have not been successful. All the spots, however, are not of the same nature. In some cases they appear to consist almost wholly of white mica. In others, after much observation and comparison with other contact-specimens, I am of opinion that, as suggested by Harker and Marr, andalusite is the mineral being formed. But that mineral, in definite recognizable form, does not occur in any of my sections. In other slides, again, the material of the spots is quite different from either of the preceding and quite beyond any attempt at identification.

Messrs. Harker and Marr are of opinion that probably a good deal of felspar is formed in these altered flags, together with the mosaic of regenerated quartz. There are few questions of greater interest than that of the formation of *new* felspar in sedimentary rocks, whether by contact or by regional metamorphism, and any instance brought forward is important. Such instances are not very numerous, and some of them do not appear to be by any means fully accepted. In the case of these rocks in Wasdale Beck I have made every effort to obtain proof of the occurrence of felspar, but without any success. All the grains of the mosaic are perfectly limpid. Many suggest felspar by their outlines, as stated by Harker and Marr, and there is decidedly an impression produced that the mineral is there. But of scores of tests in convergent light, made on promising-looking grains, not a single one has given proof of a biaxial mineral, which would in this case be sufficient confirmation. The sections for studying this class of rock are necessarily very thin; but with equally thin slices of some of the neighbouring altered volcanic rocks with quartz-felspar mosaic, it is quite easy to pick out and identify the felspar grains. Although it is by no means unlikely that felspar is present, I prefer to consider it as not proved, so far as any of my own specimens are concerned.

Although on a minuter scale, great interest attaches to the changes which are undergone, during the alteration of rocks in this class, by the minerals consisting wholly or largely of titanic acid; and these flags of Wasdale Beck are specially suited for observing these changes, as we may here see several of them together which have been noticed elsewhere singly by different observers at different places.

At the falls near the hotel, where alteration is already well advanced as regards formation of brown mica and is distinctly commencing as regards regeneration of quartz, we still see the original "clay-slate needles" in considerable numbers. They are of very small size. The only change seems to be that they are not as equally diffused as in the original rocks, having apparently commenced to disappear at some parts of each slide examined. A few yards higher up, with much increased development of brown mica and regenerated quartz, these minute rutiles have disappeared; and in due course, as the new limpid mosaic is developed, we note the appearance of rounded and ovoid grains of rutile and of crystals of that mineral, which are much larger and relatively thicker and blunter than the original needles. These things, together with other indeterminable granular and microlithic bodies, appear in the grains of regenerated quartz and assist in distinguishing it from the still remaining clastic fragments.

At another stage still larger rutile crystals are seen in groups and interlacing clusters, mustering strongly at some parts and wholly absent from others.

In some of the sections where "spots" are strongly developed, clusters of beautiful little crystals of anatase are seen, as recorded by Harker and Marr.[1]

At the time when they introduced the note on this mineral into their paper it had been only seen by me in one section. I now have several, from different points along the beck, in which it is plentifully represented, not only as clusters in the spots, but also scattered about in the mosaic.

This appears to be a rare case, as Mr. Harker tells me that anatase is only once previously recorded (by Lossen) as a contact-mineral. It is a very interesting fact that titanic acid as original slate-needles is reabsorbed in some manner, and then reappears, in one and the same rock, either as rutile or as anatase, and that the latter clusters thickly in special spots.

Another form in which the titanic acid reappears is in combination with lime and silica as sphene, granules of which are abundant in some of the sections, though none is seen till after the disappearance of the original rutile-needles.

Again, at some parts of these rocks we have abundant minute transparent plates of ilmenite, largely as perfect hexagonal crystals, thickly grouped together in the spots in just the same manner as we have the anatase. This appearance of ilmenite in contact-rocks, with the corresponding disappearance of original rutile, is pointed out by Rosenbusch ("Massige Gesteine").

Finally, where veins of white mica are formed, we may see, in and along the edges of these little veins, large crystals and grains of rutile, many times larger than any so far mentioned, resembling in size and form those which are seen so abundantly in some schists.

The occurrence of anatase in this manner being apparently so rare, it may be of interest to mention that I have recently observed another instance of it. A specimen of "ash," or fine-grained tuff, which I collected this summer at Falcon Crag, Derwentwater, is made up in about equal parts of volcanic lapilli and small fragments of sedimentary rocks.[2] Some of these fragments are of *altered* rocks, the nature of the original material and of the alteration being somewhat like what we have in Wasdale Beck; and in these altered fragments several crystals of anatase occur, similar in all respects to those described. They are not clustered together, but scattered about;—the alteration of the rocks has not proceeded so far as the development of any spots.

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[1] These crystals, when best developed, are about $\frac{1}{8000}$ inch long. The form is that of a tetragonal pyramid, either simple or showing also prism-faces in narrow bands. In some of the later specimens there are large clusters consisting almost wholly of perfect, or nearly perfect crystals.

[2] These fragments of sedimentary rock are of various slates and grits. Some are very micaceous and chloritic, not very quartzy, full of "clay-slate needles," and not altered in any way. They are like many common types of slates. Others are very quartzy, more like the flags at Wasdale Beck, but even richer in quartz. The alteration of part of these is shown by formation of some of the "regenerated" quartz, and in some cases brown mica is formed, though this is not much developed, a white mica in good-sized flakes being more usual. It is in these altered, more quartzy, grits or flags, or whatever they may be best called, that the anatase crystals are seen.

NOTICES OF MEMOIRS.

I.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. CARDIFF MEETING, AUGUST 20TH TO 25TH, 1891.

LIST OF TITLES OF PAPERS READ IN SECTION C, GEOLOGY.

Professor T. RUPERT JONES, F.R.S., F.G.S., President.

The President's Address.

Sir A. Geikie.—Discovery of the Olenellus-zone in the North-west Highlands.

Sir A. Geikie.—On some Recent Work of the Geological Survey on the Archæan Gneiss of the North-west Highlands.

A. Smith Woodward.—Report of the Committee on the Registration of Type Specimens.

A. Smith Woodward.—Remarks on the Lower Tertiary Fish Fauna of Sardinia (see *infra*, p. 465).

A. Smith Woodward.—Evidence of the Occurrence of Pterosaurian and Plesiosaurian Reptiles in the Cretaceous of Brazil.

A. J. Jukes-Browne.—The Cause of Monoclinal Flexure.

A. J. Jukes-Browne.—Note on an undescribed area of Lower Greensand or Vectian in Dorset (see *supra*, p. 456).

A. C. G. Cameron.—On the Continuity of the Kellaways Beds over extended areas near Bedford, and on the extension of the Fuller's Earth Works at Woburn, Bedfordshire.

Prof. W. Boyd Dawkins.—On the Discovery of the South-Eastern Coalfield.

W. Topley.—The Geology of Petroleum and Natural Gas.

O. C. Dalhousie Ross.—The Origin of Petroleum.

Dr. H. Hicks.—A Comparison between the Rocks of South Pembrokeshire and those of North Devon.

W. A. E. Ussher.—Vulcanicity in the Lower Devonian Rocks. The Prawle Problem.

A. R. Hunt.—On the Occurrence of Detrital Tourmaline in a Quartz-Schist west of Start Point, South Devon (see *infra*, p. 465).

C. E. De Rance.—Report of the Committee on the Circulation of Underground Waters.

C. E. De Rance.—Notes on the Discovery of ***Estheria minuta*** (var. *Brodieana*) in the New Red Sandstone.

O. W. Jeffs.—Report of the Committee on Geological Photographs.

Montagu Browne.—On *Colobodus*, a Genus of Mesozoic Fossil Fishes.

C. Davison.—Report of the Committee on Earth Tremors.

Dr. H. J. Johnston-Lavis.—Report of the Committee on the Volcanic Phenomena of Vesuvius.

Sir R. S. Ball.—The cause of an Ice Age.

Dr. H. W. Crosskey.—Report of the Committee on Erratic Blocks.

Dr. H. W. Crosskey.—Notes on the Glacial Geology of Norway.

Prof. G. Frederick Wright.—Recent Discoveries bearing on the Relation of the Glacial Period in North America to the Antiquity of Man.

Dr. H. Hicks.—On the Evidences of Glacial Action in Pembrokeshire, and the Direction of Ice-flow.

H. Bolton.—On some Boulders at Darley Dale.

P. F. Kendall.—On a Glacial Section at Levenshulme, Manchester.

Prof. G. Frederick Wright.—Recent Discoveries in the Pleistocene Lava Beds of California and Idaho.

B. Harrison.—Report of the Committee on Excavations at Oldbury Hill.

Prof. J. Prestwich.—Preliminary Note on Excavations at Oldbury Hill.

Rev. E. Jones.—Report of the Committee on Elbolton Cave, near Skipton.

J. Storrie.—On the Occurrence of *Pachytheca sphærica*, Hooker, and *Nematophycus*, n.sp., in the Wenlock Beds at Ty Mawr Quarry, Rumney.

Beeby Thompson.—Report of the Committee on the Lias of Northamptonshire.

Prof. J. Hoyes Panton.—The Mastodon and Mammoth in Ontario, Canada.

E. T. Newton.—On the Occurrence of *Ammonites jurensis* in the Ironstone of the Northampton Sand Series near Northampton.

S. S. Buckman.—The Ammonite Zones of Dorset and Somerset.

G. R. Vine.—Notes on the Polyzoa (Bryozoa) of the Zones of the Upper Chalk.

Papers read in other Sections bearing on Geology:—

Section A.—Mathematical and Physical Science.

Prof. J. Milne, F.R.S.—Report of the Committee on the Volcanic and Seismological Phenomena of Japan.

Prof. J. Milne, F.R.S.—On Phenomena which might be observable, if the Hypothesis that Earthquakes are connected with Electrical Phenomena be entertained.

Section B.—Chemical Science.

Prof. W. C. Roberts-Austen, C.B., F.R.S., and *Prof. A. W. Rücker, F.R.S.*—The Specific Heat of Basalt.

Section E.—Geography.

Dr. Phené.—Changes in Coast Lines.

Section H.—Anthropology.

E. Seward.—On the formation of a Record of the Prehistoric and Ancient Remains of Glamorganshire.

II.—Remarks on the Miocene Fish-Fauna of Sardinia. By A. Smith Woodward, F.G.S.[1]

THE author referred to a series of fragmentary fish-remains from the Miocene in the neighbourhood of Cagliari, Sardinia, collected and submitted for examination by Prof. D. Lovisato. A memoir on the subject by Prof. F. Bassani (see *infra*, p. 476) had lately appeared, and the present communication contained only brief supplementary observations. In addition to the Selachian genera and species recognized by Bassani, the author identified teeth of *Scymnus*, *Oxyrhina Desori*, *Galeus*, *Aprionodon*, and probably *Physodon*, besides dermal scutes of *Trygon*. The collection comprises no evidence of ganoid fishes, and most of the remains of teleosteans are too imperfect even for generic determination. Traces of Scomberoids and Labroids occur, and there is evidence of a new species of the Berycoid *Holocentrum*. Teeth of *Chrysophrys*, *Sargus*, and other common Mediterranean genera are abundant; and a few detached yellow teeth represent an indeterminable species of *Balistes*.

III.—On the Discovery of a New Species of Fossil Fish (*Strepsodus Brockbanki*) in the Upper Coal Measures Limestone of Levenshulme, No. 6 Group, from the Railway Cutting at Levenshulme, near Manchester. By James W. Davis, F.G.S. Mem. and Proc. Manchester Lit. and Phil. Soc. [4], Vol. IV. 1891 (reprint paged 1–3).

VERY fragmentary remains of *Strepsodus* in the collection of Mr. W. Brockbank, F.G.S., form the subject of this note. "The teeth differ from those of *Strepsodus sauroides*, Young, in the greater breadth in proportion to the length; the surface striation is similar in the two, with the exceptions that in *S. Brockbanki* the striæ are larger, and there is no evidence of bifurcation, and whereas in *S. sauroides* the base of the crown is ovoid and laterally compressed, and the apex twice bent nearly at right angles, in this species the base of the crown is circular, and the point is not twisted to the same extent."

IV.—On the Occurrence of Detrital Tourmaline in a Quartz Schist west of Start Point, South Devon. By A. R. Hunt, M.A., F.G.S.[1]

WHILE examining the Devonian cliffs near Street Gate at the north-east end of Slapton Sands, South Devon, in company with Mr. W. A. E. Ussher, F.G.S., the author selected a hard micaceous sandstone of fine grain, occurring as a band between softer rocks, for comparison with a micaceous quartzite or quartz-schist, previously noticed by Mr. Ussher at a point on the coast south of Start Farm and west of Start Lighthouse. The quartz-schist occurs as an impersistent band among the mica-schists west of Start Point.

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[1] Abstract of paper read before Section C (Geology), Brit. Assoc., Cardiff, 1891.

Mr. A. Harker, F.G.S., on examining the sandstone, at once pointed out the presence of tourmaline and white mica, of detrital origin; and considered that the rock had the appearance of having been derived from a tourmaline-bearing granite.

On a careful examination of two slides of the quartz-schist,[1] the author detected a single grain of tourmaline. Six additional slides were forthwith prepared, and detrital tourmaline was found in them all. One of these slides contains a pellucid grain of quartz with fluid inclusions and active bubbles; another contains a grain crowded with hair-like inclusions and with one fluid inclusion whose bubble is easily moved by the heat of a wax match. Both these grains could be easily matched in the quartzes of different granites.

The derivation of the quartz-schist from granites of more than one character, but one of which must have been schorlaceous, seems clearly indicated.

The above facts have two distinct bearings, viz. as to the age of the metamorphic schists of South Devon, and as to the derivation of the tourmaline.

The two rocks under consideration, viz. the quartz-schist and the Devonian sandstone, are related to each other in four particulars, insomuch as they contain four constituents common to both, viz. detrital tourmaline, detrital mica, quartz of fine grain, and iron.

It seems difficult to avoid the conclusion that such similar rocks must be of like age and derivation; and that as the sandstone is undoubtedly Devonian, the quartz-schist, one of the metamorphic schists of South Devon, must be of Devonian age also, and not Archæan, as has been supposed by some geologists.

The derivation of the tourmaline is a more difficult question. Whatever may be the age of the mass of the Dartmoor granites, those of a schorlaceous character seem to be post-Carboniferous. Moreover, no tourmaline has been noticed in the granites trawled in the English Channel. There is thus no recognized source of pre-Devonian tourmaline in the neighbourhood of South Devon, yet the source of derivation of the rocks under discussion could not seemingly be remote, or the tourmaline, quartz, and mica could scarcely have kept together. The tourmaline granites of Cornwall would meet the case, if any of these are of pre-Devonian age; but on this point the author has no information.

Besides the tourmaline observed in the rocks at Street Gate and Start Point, the author has noticed the same mineral, occurring in the same way, in a sandstone from near Tinsey Head in Start Bay, and in a sandstone from near Charleton on the Kingsbridge estuary, both of Devonian age.

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[1] The hand-specimen selected for slicing was kindly placed at the author's diposal by Mr. A. Somervail, of Torquay.

REVIEWS.

I.—The Lake-Dwellings of Europe, being the Rhind Lectures in Archæology for 1888. By Robert Munro, M.A., M.D. Royal 8vo. pp. xl. and 600, with 199 composite Illustrations, containing 2172 separate Figures, and 14 Maps and Plans. (London: Cassell & Company.)

THE study of Prehistoric Man, or the attempt to discover evidences of the early races who first occupied Europe in Prehistoric times, and to interpret these relics by a knowledge of the habits and customs of existing aboriginal races, may certainly be said to have been initiated near the end of the first half of the present century. But the most important discoveries were actually made within the second half; discoveries so vast in importance in connexion with the history of the human race as to excite the attention of the whole scientific world and to result in the development of a literature devoted entirely to Prehistoric Archæology.

In Denmark, England, Belgium, France, Switzerland and elsewhere, the stream of new light seemed never ending. Yet many of these novelties had really been discovered long, long, before, but no one seemed disposed to notice them, nor was any curiosity expressed when their discovery was announced. Then why this sudden enthusiasm? Simply because the public mind had become educated and was *beginning* to take an interest in natural science, and men like Falconer, Prestwich, Lyell, John Evans, Lubbock, Pitt-Rivers, Franks, Boyd-Dawkins and Pengelly in England; Lartet and Christy in France; Keller in Switzerland, and very many others, were able, not only to discover, but to correctly interpret and describe, what they found or saw. It is to the labours and publications of these men that we owe the great advance in Anthropological knowledge to which we have attained, and to the general intelligent interest taken by the public at large in the history of early man in Europe.

Following the sequence of these discoveries, we find primitive man wandering and homeless, save for some cave, or rock-shelter; here as a bold palæolithic hunter of the Mammoth and the Woolly Rhinoceros, or disputing his right to some cave with the Bear, the Lion, or the Hyæna. There, as the humble shore-dweller, feasting upon the oyster or the whelk, the limpet, or the mussel. Or, again, engaged in making excellent harpoons out of Reindeer-antlers, and manufacturing needles out of the leg-bone of the Horse; leaving behind him abundant evidence of his prowess in the chase in the form of well-carved or incised figures of these and other animals, on their antlers or pieces of their bones; unrivalled as a skilful worker in flint and other stone, from the rough to the polished implement of perfect beauty. Nor is this all,—for in those districts of Europe where rivers and lakes abound, we learn that certain Neolithic peoples—probably at a somewhat later period—occupied their shores and banks as mixed fishers, hunters, and even as early agriculturists—if their garden-patches may have deserved that name; and being possessed of more worldly gear than the earlier Cave-Dwellers, and, though living in communities, were yet a peaceful and less warlike race; they had invented a system of fortified habitations, raised above the level of the water, by means of piles driven into the bed of the river or lake, bearing a platform of horizontal timbers upon their tops, on which the dwellings were placed. These lacustrine habitations were sufficiently far from the shore to protect them from enemies, and yet near enough to be approached by a narrow bridge which could easily be removed or destroyed in case of a hostile attack from the land.

The relics of these dwellings first attracted attention at Ober-Meilen, on the east shore of Lake Zurich, during the winter of 1853–54, when, owing to the extreme lowness of the water of the lake, the heads of numerous wooden piles were exposed, around which were portions of Stag's antlers, stone hatchets and other implements which excited some curiosity. Other finds followed and led to the subject being taken up by Dr. Ferdinand Keller, President of the Antiquarian Association at Zurich, to whom the world is indebted for making known one of the most remarkable archæological discoveries of this century,—a discovery which in its consequential results is unique for the variety and wealth of materials with which it has illustrated that singular but long unknown and forgotten phase of prehistoric civilization in Europe, which found its outcome in the habit of constructing dwellings in lakes, marshes, etc.

Dr. Keller's researches were most extensive and were made known in a series of exhaustive reports sufficient to fill many volumes. They were first translated and the plates redrawn and published in English by Mr. John Edward Lee, F.S.A., in 1866; but, in ten years, Keller's continued researches in Switzerland had so grown, that, to keep pace with them, a second edition was required extending to two large volumes.

"Since then, however (1878), the results of lacustrine researches have been greater and more important than during any previous corresponding period. The 'Correction des Eaux du Jura,' together with various harbour alterations in the lakes of Zürich, Geneva, etc., have been the means of enormously increasing the lacustrine collections of Switzerland. In North Italy not only have new and remarkably interesting lacustrine stations been discovered and exhaustively investigated, as Lagozza and Polada, but the researches in the terremare have been such as to entirely alter the previous opinions held in regard to them. Nor has the progress in this field of research in many other countries in Europe been scarcely less important: in proof of which I have only to mention the additions made to the Scottish and Irish crannogs; the curious fascine-structures brought to light in Holderness, Yorkshire, the novel revelations extracted from the *terp*-mounds in Holland, and other low-lying districts on the coast of the German Ocean; the greatly extended and more accurate details of lacustrine structures in North Germany; the discovery in Hungary of prehistoric mounds analogous to the terramara deposits of Italy, etc. In short there is hardly any corner of the lake-dwelling area in Europe which has not yielded new materials, throwing more or less light on this strange phase of Prehistoric life."

The present volume, Dr. Munro tells us, originated with the Society of Antiquaries of Scotland, who offered him the Rhind lectureship in Archæology for 1888, and suggested that the course of six lectures should be on the "Lake-dwellings of Europe." These lectures are here printed in extenso, and are very copiously illustrated by drawings of all the most typical antiquities discovered, prepared as far as possible from the actual objects by Dr. and Mrs. Munro, who perambulated the whole of Central Europe with note- and sketch-books in hand visiting, as far as practicable, the sites of lake-dwellings, and searching museums and libraries wherever they thought such relics or records were to be found.

"The eastern limit," we are told, "of the region thus visited may be represented by a line drawn from Konigsberg to Trieste, passing through the intermediate towns of Krakow, Buda-Pesth, and Agram. The materials brought together from this area are, to a very considerable extent, absolutely new to British archæologists." Care has also been taken, as far as possible, not to repeat illustrations given by Keller's translator, except where the objects are the best or the only representatives of their kind. To show how well Dr. Munro has carried out his task, and how great is the area over which he has travelled, we must consult the work itself; indeed, it is one which every student of prehistoric archæology must possess in order to be posted up to date in all the researches which have been carried on since the date of the last English edition of Keller's work.

The first lecture gives an account of the earliest discovery of Lake-dwellings; the settlements of the shores of Lake Zürich; those of Western Switzerland and France (pp. 1–109). Some idea may be formed of the vast number of objects of ornament, weapons, and articles of domestic use, in stone, bronze, earthenware, iron, bone or wood, delineated in this work, when we find that in the 23 page-illustrations to the first lecture alone, there are 517 separate figures engraved.

The second lecture (pp. 110–185) deals with the settlements in Eastern Switzerland, the Danubian Valley, and Carniola. Here is given an account of some curious traps made of wood which have been found in settlements as widely separated as Ireland, North Germany, Styria, and Italy, which it is suggested may have been used as Beaver or Otter traps. As many as 52 individual remains of the Beaver were obtained at Laibach alone, where these supposed beaver-traps were also met with. Four hundred and fifteen objects are figured in the text to illustrate this lecture.

The third lecture (pp. 186–276) treats of the Lake-dwellings and pile-structures in Italy, including the Terramara Settlements in the Po Valley, which are illustrated by 527 figures in the text.

The fourth lecture (pp. 277–348) describes the remains found at

La Tène and in the Lake of Paladru: also the Lacustrine and Marine dwellings in the Lower Rhine District and in North Germany; two hundred and eighty-five of the antiquities from which are illustrated in the text.

The fifth lecture (pp. 349–494) treats of the Lake-dwellings of Great Britain and Ireland, describing the Scotch and Irish Crannogs, etc., with two hundred and seventy-four illustrations.

The sixth and last lecture (pp. 495–554) deals with the Lake-dwellers of Europe, their Culture and Civilization; and is illustrated by 154 figures; making a total of 2172 objects figured, besides fourteen maps and plans.

The protracted period of time represented by these pile-dwellings is attested both by their wide geographical distribution, and by the fact that some flourished at a time when the use of metals was entirely unknown to their inhabitants, as all the tools and weapons recovered from the débris were made of such materials as stone, bone, or antlers of deer, etc. The substitution of bronze for these, marks a decided change in the culture and civilization of the Lake-dwellers—a change which becomes further modified by the introduction of iron.

"We have thus a great variety of lake-dwellings, distinguishable from each other generally by the character of their industrial remains, according to the particular civilization which prevailed at the period of their habitation, some dating back from the pure Stone age, others from the Bronze age, while others again bear the imprint of various later civilizations, as Roman, Celtic, Carlovingian, Slavish, etc., clearly proving their continuance in various parts of Europe for a very long period extending from the Neolithic age to the dawn of written history."

"In hazarding an opinion as to the original founders of the lake-dwellings of Central Europe (writes Dr. Munro), I would say that they were part of the first Neolithic immigrants who entered the country by the regions surrounding the Black Sea and the shore of the Mediterranean, and spread westwards along the Danube and its tributaries till they reached the great central lakes. Here they founded that remarkable system of lake-villages whose ruins and relics are now being disinterred as it were from another or forgotten world.

Those following the Drave and the Save entered Styria, where they established their settlements on what was then a great lake at Laibach. From this they crossed the mountains to the Po valley, where they founded not only the pile-villages, but subsequently the terremare. The Danubian wanderers having reached the upper sources of the Danube, crossed the uplands by way of Schussenried, and arrived on the shores of Lake Constance, from which they quickly spread over the low-lying districts of Switzerland. From Lake Neuchâtel, still continuing a westward course, they reached the Rhone Valley by way of Morges, where they erected one of their earliest and largest settlements. From the Lake of Geneva they had easy access to the lakes of Annecy and Bourget."

"After the collapse of the great Lake-villages it is not singular to find that a knowledge of the system remained among the surrounding nationalities, which subsequently germinated into activity in various sporadic corners, and produced not only the Scottish and Irish crannogs, but the analogous remains in Friesland, North Germany, Paladru, etc. As the great extinct mammals are known to have lingered in the recesses of mountain-ranges and other secluded localities, so the artificial islands or crannogs and other lake-habitations of the Iron Age are but the deteriorated remnants of a doomed system which, like every dying art before final extinction, passed through a stage of decay and degeneration." Dr. Munro's book has afforded us no small pleasure and profit in its perusal, and we congratulate both Dr. and Mrs. Munro on the excellence and abundance of the illustrations, which bespeak a real love of the graphic art.

A descriptive catalogue of all the objects illustrated in the text, also a copious index, and an exhaustive bibliography of lake-dwelling researches in Europe, give to Dr. Munro's volume a completeness which is, alas! too often wanting in scientific works.

II.—DESCRIPTIONS OF SOME NEW OR PREVIOUSLY UNRECORDED SPECIES OF FOSSILS FROM THE DEVONIAN ROCKS OF MANITOBA.

By J. F. WHITEAVES. From Trans. Roy. Soc. Canada, Section IV. 1890, pp. 93–110, Plates IV. to X. (Montreal, Dawson Brothers.)

WITH the exception of *Stringocephalus Burtini*, the species described in the present paper are new. They are as follows:—

PELECYPODA.

Modiomorpha attenuata.
Megalodon subovatus.
Orthonota corrugata.

GASTEROPODA.

Pleurotomaria goniostoma.
Euomphalus Manitobensis.

CEPHALOPODA.

Orthoceras (*Thoracoceras*) *Tyrrellii.*

CEPHALOPODA—*continued.*

Actinoceras Hindii.
Gomphoceras Manitobense.
Cyrtoceras occidentale.
Homaloceras (gen. nov.) *planatum.*
Tetragonoceras (gen. nov.) *gracile.*
Gyroceras Canadense.
,, *filicinctum.*
,, *submammillatum.*

In the Report of Progress of the Geological Survey of Canada for 1874–75 (p. 68), "a Brachiopod resembling *Stringocephalus*" was recorded from "the western shore of Dawson Bay," Lake Winnepegosis, "from slabs apparently derived from the neighbouring cliffs."

Collections made during 1888 and 1889 by the author and Messrs. Tyrrell and Dowling in the neighbourhood of Lakes Manitoba and Winnepegosis, included a remarkably fine series of specimens which the author considers to be specifically identical with the *Stringocephalus Burtini* of British and European areas. "They present nearly all the variations in external form which that protean species assumes," and some exhibit the internal characters. "The only appreciable characters in which the Manitoba specimens seem to differ from British or European ones are, that in the former the loop in the dorsal valve is much broader proportionately, and the muscular impressions, which, however, are very indistinctly defined, were probably longer."

At Lakes Manitoba and Winnepegosis, all the species described in the paper, with the exception perhaps of *Gomphoceras Manitobense*, and *Gyroceras submammillatum*, were associated with this Brachiopod, a shell which, in Europe, occupies a definite horizon in the Middle Devonian.

Although based upon very meagre material, the species referred to the genus *Modiomorpha* can, it is believed, "be recognized at a glance by its unusually large size and narrowly attenuated form, although it is by no means certain that it is correctly referred to this genus." Since the hinge is not well preserved in any of the specimens collected, the species assigned to the genus *Megalodon* is provisionally referred to that genus on account of its "strong resemblance in external structure to the *M. truncatus* and *M. rhomboidalis* of Goldfuss from the Devonian rocks of the Eifel."

Of the two new Gasteropods which are described, viz. *Pleurotomaria goniostoma* and *Euomphalus Manitobensis*, the latter is stated to be one of the most abundant and characteristic fossils of the Devonian rocks at Lakes Manitoba and Winnepegosis. In addition to detached opercula, one specimen has been found in which "the shell is so broken as to show its operculum *in situ*, though a little displaced from its normal position."

A remarkable species of *Orthoceras* is described under the name *O.* (*Thoracoceras*) *Tyrrellii*. It has a marginal siphuncle and is ornamented with transverse plications and longitudinal ridges, each point of intersection of a transverse plication with one of the longitudinal ridges being marked by a short, slightly curved spine. The author observes that it "seems to belong to that group of the Orthocerata for which Fischer de Waldheim proposed the generic name *Melia* in 1829, though, finding this preoccupied, he changed it to *Thoracoceras* in 1844." Fischer gave as the type of the genus *Thoracoceras*, *Th. vestitum*—a species with a rather small, submarginal siphuncle, and ornamented with spinose, longitudinal ridges. Although adopted by some subsequent writers, the genus has been variously interpreted. According to Prof. Hyatt, who regards the genus as valid, it includes "all those longicone species in which the ridges become spiny or are roughened by the prominence of the transverse striæ or ridges," and also such forms as *Cyrtoceras corbulatum*, Barrande, *Cyrt. canaliculatum*, de Koninck and *Cyrt. Puzosianum*, de Koninck. The author adopts *Thoracoceras*, but regards it only as a subgenus of *Orthoceras*.

The figure given of *Gomphoceras Manitobense* certainly bears out the author's statement that the anterior end of its body-chamber appears to be more like that of *Poterioceras*. The species, however, is rather doubtfully referred to the genus *Gomphoceras* on account of its general resemblance to the *G. eximium* of Hall.

Two new genera of Cephalopoda are described, viz. *Homaloceras* and *Tetragonoceras*. The former is thus characterized—"Shell consisting of a slender tube which is broadly and strongly arcuate, curved in the same plane and much flattened laterally, its venter or outer border being very narrow, truncated and depressed in the centre. Sutural line consisting of two very narrow saddles with an equally narrow sinus between them on the venter, a broadly concave sinus or lobe on each of the sides, and a rather narrow saddle on the dorsum; siphuncle in the only species known, cylindrical, exogastric, and placed near the venter or outer and convex margin. Body-chamber long, occupying about one-third of the entire length."

The author is doubtful as to which of Prof. Hyatt's families the genus should be referred, but he is "inclined to regard it as an extremely aberrant member of the Hercoceratidæ."

The other new genus—*Tetragonoceras*—is proposed for a loosely coiled shell with a quadrangular transverse section. "*Cyrthoceratites*" *tetragonus*, d'Archiac and de Verneuil, from the Middle Devonian of the Eifel, also has a quadrangular transverse section, but according to Prof. Hyatt's statement, this species, which he places in his genus *Centroceras*, appears to have been a true close-coiled Nautiloid.

Of the three new species of *Gyroceras*, *G. Canadense* and *G. filicinctum* are very like the *G. Eifelense* from the Middle Devonian of the Eifel, while *G. submammillatum* bears a most striking resemblance to an internal cast of the well-known *G. ornatum* from the same horizon and locality. G. C. C.

III.—LANDSCAPE GEOLOGY: A PLEA FOR THE STUDY OF GEOLOGY BY LANDSCAPE PAINTERS. By HUGH MILLER, of H. M. Geological Survey. 8vo. pp. 63. (Edinburgh and London, William Blackwood and Sons.)

THE pictures exhibited in the Royal Academy have at times been subjected to criticism in the pages of "Nature." The representation of clouds, waves, the apparent size of the Moon, and the delineation of rock-structure, have in turn undergone praise or stricture; and it would seem that the unhappy Landscape Artist need make acquaintance with Astronomy and Meteorology, with Geology and Physical Geography, and with Botany and Zoology, if he or she wishes to escape the scientific critic. But the plea of the Artist is that he essays to represent things, not necessarily as they are, but as they appear to him; and Mr. Briton Riviere (quoted in the work before us) says, "It is the personality of the artist, the impress on the work of the artist's own mind and intention, adequately expressed, which gives the art." Hence, "It is possible for a picture to be scientifically true and have no art at all in it; and, on the other hand, to contain several scientific blunders, and yet to be a great work of art."

No one will find fault with the Artist for representing things as they appear to him; but in pictures that aim to be topographical, it is desirable that the outlines of hill and mountain, of crag or scarp, should bear some relation to the anatomy of the earth. Mr. Miller disclaims any desire to go geologizing through the picture galleries, though he agrees with the critic who says, "Is it too much to ask that the artist shall not give us *slate* where there is only *gneiss*, or granite boulders where there are none?"

The author remarks that Geology, like all the teachings of Nature, will be found to be fraught with Poetry, and he urges that it is possible to convey some poetic expression of past time as well as of modern agents in the delineation of both mountains and rocks. He points out the position of blocks in a torrential stream, with their plane sides sloped gently towards the current; and to the shapes and altitudes of boulders on a hill slope. Artists, he says, as a rule look upon rocks as in themselves rather expressionless objects, but he urges that much expression may be given to them when attention is paid to their texture, structure, and colour. He would "make the varying aspects and colouring of rocks the object of special studies—not forgetting that it is possible to find varying expression, and, so to speak, a different handwriting, or perhaps hidden *ciphers*, in the same rock from day to day." In these and other remarks he endeavours to show that Geology taken in connexion with the physical aspect of the country may be studied as an exercise for the imagination.

He would wish the artist to "open his mind to ideas of strange vicissitude and awful age in connexion with rocks and mountains," though the mountains be depicted "not as rent and torn by disrupting forces from within, but as wasted and sculptured by the forces of 'denudation' at work without."

In this way Mr. Miller maintains that some acquaintance with Geology would be to the Landscape-painter what a knowledge of History is to the painter of historical subjects. It would help and inspire him in giving expression to his subject.

It is often urged that Geology, dealing for the most part with pre-human periods, can yield little material for poetic minds. The author himself observes, "Ruins are pregnant with human associations; rocks have none." But Geology blends its History with that of Man and many associations may be called up, directly or indirectly, in the imprints of the past upon the present.

Referring to the Scenery of Scotland Sir Archibald Geikie has remarked that if the Geologist "can only present his results in simple and intelligible guise, they will be found in no degree to lessen the charm of the scenery. He cannot diminish the romance that hangs like a golden mist over the country; on the contrary, he reveals another kind of romance, different indeed in kind but hardly less attractive, wherein firth and fell, mountain and glen, glow with all the fervour of a poet's dream." The same writer adds, "Let me, however, assure him [the reader] at the outset that if the human associations of the land are uppermost in his mind as he wanders through it, my sympathies are wholly with him." A Geology made easy for Landscape Artists is still a desideratum. There is need of a work that would simply describe types of rock-structure and the relations between various rocks and the form of the ground. Mr. Miller has in the little book before us discussed his subject in such choice language and in so poetic a spirit, that we are led to hope that he may supplement his *plea* by some more practical guide for the use of the Landscape-painter.

IV.—Tertiary Fishes.

1. Neue Untersuchungen an tertiären Fisch-Otolithen. By Prof. Dr. Ernst Koken. Zeitschr. deutsch. geol. Ges. 1891, pp. 77–170, Pls. I.–X. Woodcuts 1–27.
2. Palaeoichthyoložki Prilozi (Collectae Palaeoichthyologicae). Part II. By Dr. D. Gorganović Kramberger. Rad jugoslav. Akad. 1891, pp. 73, Pls. VIII.
3. Contributo alla Paleontologia della Sardegna. Ittioliti Miocenici. By Prof. Francesco Bassani. Atti R. Accad. Sci. Napoli, Ser. 2, Vol. IV. Mem. No. 3, 1891, pp. viii.+60, Pls. II.
4. Ueber einen mit hyperostotischen Bildungen versehenen Schädel eines subfossilen *Pagrus* von Melbourne. By Prof. Dr. W. Dames. Sitzungsb. Ges. naturf. Freunde Berlin, 1890, pp. 162–167, Woodcut 1.
5. Sciame di Pesci fossili ricoprente una Lastra di Calcare marnoso. By Dr. Carlo Pollini. 8vo. pp. 1–8, Pl. I. (Milan, 1891.)

DR. ERNST KOKEN, now Professor at Königsberg, is continuing his well-known researches in the determination of fish-otolites; and his latest contribution to the subject, mentioned above, concludes with some general remarks of much interest. It is a surprising fact that a large number of groups of fishes that must have existed from early Tertiary times are scarcely, if at all, represented by tolerably complete fossil skeletons, or by readily recognizable fragments. If, however, Dr. Koken's determinations of the fossil otolites are well founded, this circumstance is proved to be merely another example of the imperfection of the "geological record"; and whole groups of which the palæontologist has hitherto known almost nothing are shown to occur in comparative abundance at certain horizons in several classical localities. Of the Gadidæ much evidence of the genera *Gadus*, *Morrhua*, *Merlangus*, *Raniceps*, and *Merluccius* is recorded, especially from the Oligocene of Germany. Many otolites of Ophidiidæ are also discovered in the same horizon, but the genus *Fierasfer* alone can be more precisely determined. Macruridæ seem to be recorded among fossil fish-faunas for the first time; otolites of *Macrurus* itself being recognized in the Pliocene of Tuscany, and some generically indeterminable specimens occurring both in the Lower Oligocene of Lattdorf and in the Senonian of Siegsdorf. With reference to the latter, Dr. Koken remarks that he does not consider either of them abyssal forms, but more nearly approaching the typical Gadidæ. Of the Anacanth Flat-fishes even otolites are scarce and very difficult to determine. *Platessa* and *Solea* are recorded from the German Oligocene, and the former also occurs in the Phosphates of Alabama. The remarkable Berycoid genera *Hoplostethus* and *Monocentris* are believed to be indicated by otolites from the Eocene of Copenhagen, the Oligocene of Germany, and the Pliocene of Tuscany; and undetermined genera of the same family are also recorded from the German Oligocene. Sciænidæ are well represented in the Upper Oligocene and Miocene. Most of the Percidæ are as yet generically indeterminable, from want of recent material for comparison; and the same remark applies to the Gobiidæ. Sparidæ, as might be expected, are widely distributed; and the Cataphracti seem to be represented in the German Middle Oligocene by the genera *Trigla*, *Peristedion*, and *Agonus*. These determinations, as Dr. Koken points out, add considerably to the material available for a discussion of the distribution of the Tertiary Teleostean Faunas in Europe; and the author is finally tempted to devote no less than seventeen pages to a treatise on otolites in reference to their bearing on the classification of Fishes.

Dr. Kramberger's new work is of a different character from that of Dr. Koken, being based upon a series of remains of skeletons, which are beautifully figured in the accompanying plates. It is unfortunately written in a language that few can read; but the scientific diagnoses and principal headings are also given in Latin and thus made accessible to all. There are seven short chapters relating to as many fish-faunas, chiefly Tertiary; and several new species are determined. The first chapter deals with Cretaceous species from Lesina, already described under the names of *Clupea lesinensis*, *Scombroclupea macrophthalma*, *Thrissops microdon*, *Hemielopopsis Suessi*, and *H. gibbus*. The second chapter is more extensive and relates to the marine fishes of the Aquitanian Formation of Styria. Here several new species are determined and named respectively *Labrax latus*, *L. Mojsisovicsi*, *L. sagorensis*, *Sparnodus inflatus*, *Lichia alta*, *Zeus Hoernesi*, and *Z. robustus*. A supposed *Leuciscus* (*L. eibiswaldensis*, sp. n.) is also represented by an imperfect skeleton from the freshwater beds of Eibiswald in Styria, associated with *Leuciscus macrurus*, Ag., and *Gobius brevis*, Ag. sp. Teeth from the Miocene of the neighbourhood of Agram are discussed in chapter iii. and referred to *Chrysophrys*, *Aetobatis*, *Hemipristis serra*, and *Sphyrna* cf. *prisca*. The fish-remains of the well-known Sarmatian beds of Croatia form the subject of chapter iv. and include some new forms, notably *Syngnathus affinis*, *Apostasis* (gen. nov. Acronuridarum) *Sturi*, *A. croatica*, *Scomber* (*Auxis*) *sarmaticus*, *Blennius fossilis*, *Atherina sarmatica*, and *Labrus* (*Crenilabrus*) *Woodwardi*. The generic name *Metoponichthys* is relegated to the synonymy of *Proantigonis* among the Carangidæ. Chapters v. to vii. are brief notes on fragments, of which the most striking are the remains from the late Tertiary beds near Sofia, Bulgaria, described under the new specific name of *Lucioperca Skorpili*.

Thanks to the explorations of Prof. Dr. D. Lovisato, of Cagliari, some information concerning the Miocene fish-fauna of Sardinia is now forthcoming. In the memoir quoted above Prof. Bassani has employed the new material not only for detailed descriptions but also as the basis of an elaborate treatise on the distribution of some of the commonest Tertiary Selachian teeth. *Carcharodon megalodon*, *C. auriculatus*, *Galeocerdo aduncus*, *G. minor*, *Hemipristis serra*, *Lamna salentina* (including "*Otodus Lawleyi*"), *Notidanus primigenius*, *Odontaspis contortidens*, *O. cuspidata*, *Oxyrhina hastalis*, *Sphyrna prisca*, and a species of *Squatina* are recognized among the Selachian teeth; and unsatisfactory fragments of dentition of Teleostean fishes are assigned to *Chrysophrys cincta*, *Dentex*, and *Thyrsites Lovisatoi* (sp. nov.).

Finally, two smaller papers may be mentioned among recent interesting contributions to knowledge of Tertiary fishes. Dr. Dames has described the skull of a sub-fossil *Pagrus* from the neighbourhood of Melbourne, Australia, giving a good figure and discussing the remarkable hyperostoses by which the cranial roof is characterized. Dr. C. Pollini publishes a photograph of a slab of marl, probably from Aix-en-Provence, in the Genoa City Museum, displaying a shoal of *Lebias cephalotes*, Ag. A detailed description of this fish is given, and some remarks are added as to a possible explanation of the occurrence of so large a number of individuals in so small an area. Dr. Pollini has omitted to observe that Dr. Sauvage some years ago (Bull. Soc. Géol. France [3] vol. viii. p. 445) proposed to place *L. cephalotes* in a new genus, *Prolebias*—a subject that might have been appropriately discussed after the detailed description. A. S. W.

V.—The Lower Permian Fishes of France.

Etudes des Gîtes Minéraux de la France: Bassin Houiller et Permien d'Autun et d'Epinac. Fasc. III. Poissons Fossiles. By Dr. H. E. Sauvage. 4to. pp. 31, Pl. V. (Paris, Imprimérie Nationale, 1890.)

THOUGH dated 1890, this interesting work on the Permian fishes of the neighbourhood of Autun has only just been brought to our notice. It is a well-illustrated, detailed account of a fish-fauna, of which much has long been known; and it forms an appropriate supplement to the memoirs of Prof. Gaudry, who has devoted special attention to the associated Amphibian and Reptilian fossils.

After a brief historical and bibliographical sketch (in which the only omission we detect is that of Egerton's well-known memoir in the sixth volume of the Geological Society's Quarterly Journal), Dr. Sauvage proceeds at once to a detailed description of the species. The majority of the forms are Palæoniscid fishes related to the Lower Permian genera, *Palæoniscus* and *Amblypterus*; three only being referable to the lower orders, namely, an undetermined species of *Acanthodes*, a Pleuracanth Elasmobranch, and a Dipnoan fish. The generic name *Amblypterus* is employed in almost as extended a sense as is adopted by Traquair, and five species are determined, including two novelties. The so-called new genera *Ædua* and *Archæoniscus* (this name preoccupied by a well-known Isopod) are based on characters which we venture to regard as of very doubtful value; and we are inclined (with Traquair) to disbelieve that the fin-rays in any of these fishes are invested with scales, as Agassiz originally maintained, and as is now re-asserted by Dr. Sauvage. Moreover, we cannot perceive much difference between the type-specimen of *Ædua Gaudryi* and Egerton's *Palæoniscus Beaumonti*, which Dr. Sauvage appears to have overlooked. One small new species is assigned to *Palæoniscus*, and another may possibly represent *Rhadinichthys*. Finally, among the Palæoniscidæ is placed the fish originally named *Pygopterus Bonnardi* by Agassiz, not hitherto described. It is gratifying at last to have a good figure and description of the fossil to which this name refers; but we fail to recognize the slightest resemblance to *Pygopterus*, and until Dr. Sauvage is able to bring forward further evidence on the subject, we shall continue to believe that *P. Bonnardi* is founded on part of the caudal region of a Pleuracanth Elasmobranch.

Of the Dipnoan fish described by Gaudry as *Megapleuron Rochei*, and of the Pleuracanth spine named by the same author *Pleuracanthus Frossardi*, Dr. Sauvage merely reproduces the original descriptions and figures. No allusion is made to Dr. Anton Fritsch's observations on *Megapleuron*, in which the rhomboidal scales are correctly, as we consider, assigned to a fragmentary Palæoniscid mingled with the skeleton. This correction is of importance, for it enables "*Megapleuron*" to be recognized as a typical Sirenoid Dipnoan.

There is now hope that Dr. Sauvage's long-promised memoir on the Palæoniscid fishes of the Coal-measures of Commentry will not much longer be delayed; and we await with interest the further contribution to our knowledge of this intricate group of fishes.

A. S. W.

VI.—THE GEOLOGY OF THE NORTH-EAST OF CAITHNESS, AND A DISCUSSION AS TO THE AGE OF THE OLD RED SANDSTONE OF THE NORTH OF SCOTLAND. By JOHN WILLIAMS EVANS, LL.B., B.Sc., F.G.S. Pp. 48, with Sketch-Map. (London: Green, McAllan and Feilden, 1891.)

IN this pamphlet the author gives us the result of six weeks' field-work in Caithness. The county is occupied almost entirely by the Old Red Sandstone with coverings of Glacial Drift; it is to the older formation that attention is now directed.

Murchison divided the Old Red Sandstone of Scotland into three portions: the *Lower*, including the Arbroath flags, with *Cephalaspis*, *Pteraspis*, and *Pterygotus*; the *Middle*, including the Caithness flags, with *Osteolepis*, *Asterolepis*, *Pterichthys*, etc.; and the Upper, including the Dura Den beds, with *Pterichthys*, *Holoptychius*, etc.

Sir Archibald Geikie afterwards referred the Caithness flagstones to the Lower Old Red Sandstone, and maintained there was no evidence of any Middle division.

The observations of the author lead him to maintain that the Old Red Sandstone of Caithness belongs entirely to the Upper division; and he thus represents the succession of the Scottish Upper Old Red Sandstone:—

UPPER OLD RED SANDSTONE.	Zone of *Bothriolepis*.	Sub-zone of *Bothriolepis hydrophila*, *Holoptychius Flemingi*, and *Glyptopomus minor*.	Dura Den, etc.
		Sub-zone of *Holoptychius nobilissimus* and *Cricodus favosus*.	Scat Craig, Clashbennie, etc.
	Orcadian.	Sub-zone of *Microbrachius Dicki* and *Tristichopterus alatus*. Caithness Flags, Orkney and Shetland beds, and the Old Red Sandstone of Cromarty, Gamrie, etc. Basement Conglomeratic series.	

CORRESPONDENCE.

THE STUDY OF MAMMALS.

SIR,—I am indebted to the reviewer of this work in your last number for pointing out that the family *Tritylodontidæ* occurs twice in the systematic table. Its second occurrence is not, however, as he supposes, an inadvertent repetition, but a "misprint" for *Triconodontidæ*. Another slip occurs on p. 99, where in giving the range of *Oryx* Persia stands instead of Syria. R. LYDEKKER.

DYNAMIC METAMORPHISM "AGAIN."

SIR,—Personally I am sorry to be called upon to point out briefly that Mr. Fisher (GEOL. MAG. Sept. 1891, p. 430) has made the mistake of substituting exclusion (or "outness") in space for *logical* exclusion of one term from a series of other terms used in a train of reasoning, and that this misconception seems to run through the whole of his letter except the last paragraph. It is not Mr. Fisher's $(P-W)\,w$, but the *"last term" of the four which I had just enumerated* (p. 299), which is logically outside the other three. To say that it is outside the cubic unit (not "element") of the mass, on which the work is done, is something to which I am unable to attach any meaning at all. The energy, to which the motion of the train (in my illustration) is due, is *dissipated* (not annihilated or necessarily "converted" into some other form of energy) according to the ordinary laws of thermodynamics, having been obtained as heat from the potential energy of the fuel and atmospheric oxygen, and utilized, while in a condition of high intensity (the H_2O being the carrier of the energy), to move the piston of the engine with the load attached. In running down from a state of high intensity (in which work can be got out of it) to a state of low intensity (in which it is either absorbed by surrounding bodies, or passes off by radiation into the general entropy[1] of the universe), there is no destruction, there is only dissipation, of energy; and when it is thus dissipated, you cannot get any more work out of it. If energy were (under the conditions specified) "stored up in the train," after it had come to a standstill (the idea which was before my mind, though, I fear, not explicitly stated), the train would be, after translation, in a *position of advantage with respect to motion*, as compared with its position before translation, which is absurd. Certainly during the accelerating stage of translation energy is being stored in the train, just as you store energy in the weight of a clock in winding it up; but the same amount of energy is taken out of the train in bringing it to a standstill, just as it is taken out of the clock-weight, when it runs down. There is therefore no more energy stored in the train, after it has come to rest, than there is in the weight and works of a clock after it has run down. So in the case of the rock-mass under consideration, the source of the energy is gravitation. The work done on the rock is only a case of potential energy of position becoming kinetic, without taking aught from the force, with which gravitation continues to act upon the portion of the earth's lithosphere, to whose descent towards the earth's centre of gravity the lateral thrust is due. The clock has merely run down, as it appears to me. Work has been done, and that work is the equivalent of the *potential* energy. In the infinitesimal amount of molecular change in the iron (where bad material is used), which I had overlooked, and Mr. Fisher recognizes as a case of "dynamo-metamorphism," we have indeed an excellent example (so far as it goes) of *metatropy* resulting from the action of forces purely mechanical, as I have contended for the last three years; but as this is quite a different thing from what we understand by chemical change, there is no "storage of chemical energy," which is the *crux* of the whole business.

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[1] "Entropy" in the sense in which the word was first used by Clausius.

Turning now to Mr. Harker's rather donnish letter (p. 431), in which he persists in regarding the phrases "chemical combination" and "chemical change or action" as convertible terms, I can only say that there is nothing to be gained by discussing that point further. The remainder of the paragraph is, I think, answered by anticipation in what I have already written. I certainly have maintained that ever since this globe began to cool down in space through dissipation of its energy by radiation, that cooling has been (and is still) retarded by a considerable exothermic balance of heat, as mineral changes in the lithosphere have upon the whole advanced from less stable to more stable states of combination; and in doing so I take my stand upon the broad teaching of *thermal chemistry* in its recent development. It is there that Mr. Harker must look for the "proof" that he wants. Perhaps Prof. Roberts-Austen's recent address to the Chemical Section of the British Association at Cardiff may help him. To his appeal to an imaginary *consensus* of "physicists" it is, I think, a fair reply that there are physicists and physicists; and that, although a good deal of what I have written (in the GEOLOGICAL MAGAZINE and elsewhere) may seem to some of them to be written in an "unknown tongue," I am happy to know that there are others to whom it is all perfectly intelligible. The term "intensity of heat," for example, is used to emphasize the inverse variation of absolute temperature in relation to distribution in time and mass (allowance being made for what Sir William Thomson calls "diffusity") for a *given quantity* of heat, as velocity and mass are related in the *momentum* of a body in motion. The term must stand on its own merits.

The importance of the *indirect* action of pressure in promoting chemical change, by making the existence of superheated water possible (the action of which is exceedingly well illustrated by the recent work of Kroutschoff) is not, I think, lessened by the failure of our two friends to appreciate it. There is surely in this a storage of *potential* chemical energy. Why do they refuse to use the weapon placed in their hands?

A. IRVING.

WELLINGTON COLLEGE, BERKS, 8*th September*.

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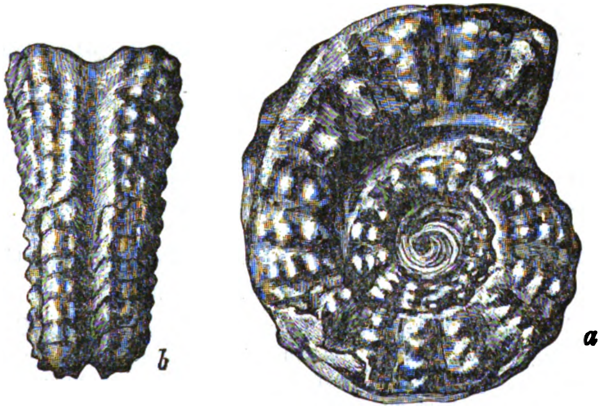
ORIGINAL ARTICLES.

I.—On *Pleuronautilus* [*Nautilus*] *nodoso-carinatus*, Römer, sp.

By Arthur H. Foord, F.G.S.

THROUGH the kindness of Mr. A. C. Seward, M.A., F.G.S., the British Museum has been put in possession of a fine specimen of this interesting species, collected by him in the Millstone Grit of Caton, Lancashire. The species is there found associated with *Nautilus* [*Pleuronautilus*] *armatus*, J. de C. Sowerby,[1] *Solenocheilus* [*Nautilus*] *latiseptatus*, de Koninck,[2] *Actinoceras* [*Orthoceras*] *sulcatulum*, M'Coy,[3] etc. These I have identified in a small collection submitted to me by Mr. Seward.



Pleuronautilus nodoso-carinatus.—*a*, lateral view, showing the ornamentation of the test; *b*, peripheral view, showing the deep median furrow, and the septa in the lower half of the figure, where the test is absent. *a*, drawn from the original specimen in the Woodwardian Museum, Cambridge; *b*, from a specimen presented to the British Museum (Nat. Hist.) by A. C. Seward, Esq., M.A., F.G.S. Both figures are about two-fifths the natural size.

From the Carboniferous Limestone, Caton, Lancashire.

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[1] In Prestwich, Geology of Coalbrookdale, Trans. Geol. Soc. ser. ii. vol. v. pt. iii. p. 492, pl. xl. fig. 8, 1840.

[2] Faune du Calcaire Carbonifère de la Belgique (Ann. du Mus. Roy. d'Hist. Nat. de Belgique, tom. ii.). p. 110, pl. xxii. figs. 1–3 ? 1878.

[3] Synop. Carb. Foss. Ireland, p. 8, pl. i. fig. 4, 1844.

Actinoceras sulcatulum and *Solenocheilus latiseptatus* are common in the Cement-stone (Upper division of the Carboniferous Limestone) of the West of Scotland. I have myself collected them in the Arden Quarry, at Nitshill, near Glasgow (see Cat. Foss. Ceph. Brit. Mus. (Nat. Hist.), pt. i. 1888, Suppl. p. 319).

The present species has been well described, but poorly figured by Armstrong (Trans. Geol. Soc. Glasgow, vol. ii. pt. i. p. 74, pl. i. figs. 6–7) under the name of *Nautilus* (*Discites*) *nodiferus*. Its identity with Römer's species is, however, beyond question.

The following is Armstrong's description:—"Shell discoidal, composed of about three gradually enlarging, contiguous, nearly subquadrate whorls, completely exposed in a moderately shallow umbilicus; back broad, rounded at the edges, and traversed in the middle by a wide and deep channel, on the sloping sides of which are two fine thread-like ridges. The remainder of the space on the back and sides of the shell is occupied by six rows of closely set, prominent, obtuse tubercles, elongated in the direction of the aperture, one row of tubercles of large size bounding the back, a double row of equal size between it and the channel, and three on the sides, which decrease in size towards the umbilicus. Surface marked with coarse, squamose, wavy lines of growth, which are arched backwards in the dorsal [=ventral, or peripheral] channel. Septa numerous, their edges arched considerably backwards on the periphery, and slightly so at the sides. Siphuncle $\frac{1}{18}$ inch diameter, central. Dimensions—width of greatest diameter 3¼ inches, width of outer whorl near the aperture, 1 inch."

The specimen presented by Mr. Seward is a valuable accession to the British Museum collection, which hitherto possessed only some small fragments of this beautiful species. These are described in part ii. of the Catalogue of Fossil Cephalopoda (1891), p. 139, where also Armstrong's description of the species is quoted.

II.—On some Recent Contributions to Precambrian Geology.

By J. F. Blake, M.A., F.G.S.

THE last two numbers of the Quarterly Journal of the Geological Society contain three communications concerning rocks which are, or are thought to be, Precambrian. Two of them are in direct attack on work of mine, and the third incidentally opposes some portion of it. The materials of any reply I may have to make are, for the most part, already published in my papers, but the bearing of these facts seems to require to be pointed out.

Taking the communications in order, the first is the Anniversary Address of the President. In this he deals, so far as my work is concerned, first with Anglesey. Sir A. Geikie states that he was not prepared by previous writings for certain results he obtained. He was much astonished to find in central Anglesey so striking a counterpart to portions of the old gneiss of the north-west of Sutherland and Ross. Speaking of the rocks which he here refers to, I wrote, "The question is suggested whether we may not touch here a piece of genuine Archæan."[1] This question Sir A. Geikie answers offhand—by the guidance of petrographical characters—aided by the hummocky surface of the ground, which latter, however, is not confined to Archæan gneisses. These petrographical characters I have described,[2] and state that the rocks have "much the aspect of a Highland gneiss"; but I do not think these characters may safely "be taken as a guide" to age. There is certainly at this moment a controversy whether they can be or not.

Sir Archibald then speaks as if *no* order of succession has been made out in the Anglesey rocks, and as if their metamorphism was the only argument for their Precambrian age in the strictest sense. I would point out that near Beaumaris the Lowest Cambrian has been shown to overlie them.

But the most important matter is the decision of the age of the rocks of the Northern District which the Director-General now considers to be Silurian. He states in the first place that "the necessity for inserting" the bounding "fault apart from any actual visible trace of its occurrence arose when the conclusion was arrived at that the rocks at the extreme north of Anglesey were essentially altered Cambrian rocks." That is to say, it is a theoretical fault. Dr. Callaway has given evidence for this fault, and my own statement is: "In this Northern District a very definite sequence of rocks may be demonstrated, ... We can follow the strike with considerable accuracy. Now, whatever part of the series we may be on from the lowest to the highest, and therefore whatever class of rock is on the northern side of the fault, as soon as we overstep that boundary we are immediately landed in black shales, which have a pretty uniform character throughout. This leaves no alternative but a fault or an unconformity; if it were an unconformity, the upper group would run parallel to the boundary, which it does not." Whoever denies this fault, let him answer this argument, and also explain how masses of Cemmaes Limestone come to be found in the basal Silurian conglomerates.

In fact, however, this line is not in modern language a fault, but a "thrust." The Director adds: "Where the supposed elliptical fault reaches the shore at Carmel's Point, the two groups of rock seem to me to follow each other in unbroken sequence." So they do to me, but things are not always what they seem. At Craig-an Knockan, Ross-shire, and elsewhere, there is an *apparent* "conformable upward succession" between Silurian rocks and the overlying gneisses. The little bands of black slate caught up in the motion in Anglesey are just what we might expect in a similar case.

Dealing next with the nature of the upper part of the rocks, some of which have yielded fossils, he states that they include "courses of black shale containing Lower Silurian Graptolites"; also "it has been supposed that the higher bands of black shale may also have been brought into their present position by faults" . . . "but this suggestion is completely disproved by the coast sections, which exhibit many thin leaves of black shale, sometimes less than an inch thick."

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[1] Q.J.G.S. vol. xliv. p. 497.

[2] Rep. Brit. Assoc. for 1888, p. 32.

I am not aware that there are any *courses* (in beds parallel to the rest) of black shale; the faults which let down the masses which are said to have yielded Graptolites may be *seen* on both sides. If there are thinner black shale bands which I have not observed, that is, no doubt, a point to be considered; but it could only be decisive if they contained Graptolites of known Silurian species.

The Director sums up by saying that this area "is proved by the evidence of fossils at its base, towards its centre, and at its top to belong to the Lower Silurian series." This sounds like a settled matter. But may I ask (or rather can I get an answer to the questions?) *What* is the lowest bed of the series above the Black Shales? What are the *names* of the supposed Silurian fossils it contains? and where may they be seen? All Sir A. Ramsay says is, "On the north by the shore a few poor fossils in irregular bands of limestone clearly indicate the Caradoc or Bala age of some of the beds." What are the names of the Graptolites which occur towards the centre? and what is the proof that *Orthis Bayleana* is a Bala fossil?

The arguments generally for the Monian age of these northern rocks are these: The volcanic group is more or less repeated in various parts of the island. It must be admitted, however, that those that most resemble these northern rocks do not clearly show their stratigraphical relations. The quartz knobs and limestone masses which are found amongst them also characterize parts which are admittedly Precambrian. It may be said against this that these may be of several ages; but it is strange that they occur only in Anglesey and amongst these rocks. Bala rocks are known in the island as black shales proved to be Bala by their *named* fossils (see Mem. Geol. Survey, vol. iii. p. 225), including *Orthides*; but none of these are *O. Bayleana*, and it would be strange that the volcanic rocks of different ages should be so similar north and south, and rocks of the same age so different in the centre. If all these arguments could be met and the volcanic group were accepted as Bala, the next alternative would be that of Sir A. Ramsay, to consider part Silurian and part Cambrian, the line of separation being obliterated by the squeezing. Otherwise, if all were Bala, we should have *identical* chloritic schists at Llanflewin and Abersant, the former Bala, the latter overlaid unconformably by Arenig grit, to say nothing of *similar* rock overlaid by the same at Carmel's Point and Treiorwerth.

I have next to notice the reasons given for rejecting the term "Monian" for a series of rocks in Scotland, of which it can be written, "No one familiar with the Dalradian rocks of Scotland and Ireland can fail to be struck with the close resemblance which these younger Anglesey schists bear to them, down even to the minutest details," and "if we are justified in grouping these Anglesey rocks with the Dalradian schists." I will not say that, if by "Dalradian" is meant the whole of the seventeen groups enumerated, these reasons *as a whole* are not well founded, since in that case it may include more than one system, of which, to judge from the statements made and if petrography can be shown in this case to be a safe guide, the Monian is certainly one. But on the next page (75) it is stated that Dalradian is proposed for the "crystalline schists" alone. In a note he says that the Monian includes Archæan gneiss. This it does not do, for if the rocks which I suggested *might* be Archæan gneiss were proved to be so, that fact would exclude them from the Monian; and if they are not Archæan gneiss they are foliated granite, and as such form no part of the system. Also that it includes "strata, volcanic and fossiliferous, of undoubtedly Bala age." But even if this could be proved, these strata could be eliminated from the Monian without destroying its existence or making it much smaller.

I now pass to the next paper by Dr. Callaway "On the Unconformities between the Rock Systems underlying the Cambrian Quartzite in Shropshire."

The first question dealt with is the age of the "Volcanic series" or Uriconian. This I concluded to be younger than the Longmynd shales. The evidence I brought forward for this was entirely original, for Dr. Callaway *never discussed the question at all,* to my knowledge, and even now he does not bring forward a shred of *positive* evidence that it is older. He says they are faulted together, in which case either might be the younger. The fact is he proved the Uriconian to be older than the Cambrian Quartzite, and *assuming* the Longmynd shales to be Cambrian also, that carried the point. Even now, I can scarcely regard its younger age as definitely proved; it may be that they are more or less contemporaneous in spite of any difference of strike. All I can say is that all the evidence available is most in favour of the volcanic series being younger; and actually Dr. Callaway's own statements are *primâ facie* to the same effect. Thus he refers to a locality on the S. E. of Ragleth (which after careful searching I failed to find) where shale like the Longmynd shale is *overlaid* by red felsite. Again, he states that near Hazler cottages the Longmynd slate near its junction with the Uriconian "has a burnt appearance and the cracks are injected with red felspar."

He next refers to the Pontesford Hill area, and says that the rocks next the rhyolite are not altered. Assuming that they are not, though to my mind they certainly are, the section is still proved by stratigraphy to lie above the whole of the Longmynd series. It is difficult to understand the gist of the concluding sentence: "As this crucial case breaks down on examination, I thought it needless to re-examine the other masses of Uriconian which appear on the line of the great Pontesford Linley fault." If it means that because in his opinion I am in error about the alteration (in common with Sir R. I. Murchison, who seems to have examined this district more thoroughly than any one else), therefore I am unworthy of credence, his paper might have conveniently stopped there.

Turning next to the unconformity in the middle of the Longmynd, he selects for sole examination the section at Narnells rock. I give the junction as it is actually seen, and this is what I say about it.

"The grit is here seen to be unconformable, but the evidence is scarcely satisfactory or conclusive. If it had been conformable, the motion which is indicated by the slickensides might easily have produced the amount of unconformity apparent." Dr. Callaway says just the same, "The grit appears to have been a little squeezed into the slate, so that here and there a trivial unconformity is apparent." According to his section, which, by the way, is not what is seen at any one spot, but is made up from several exposures, all the rocks have the same dip, so there is an apparent conformity. It is not easy to see how an apparent conformity combined with an apparent unconformity can "absolutely disprove" the reality of either one or the other. My deduction is that the evidence here is not conclusive. But other evidence is, or at least is put forward as such, but it is not tackled by the critic.

With regard to the conglomerates and grits found on the "Volcanic Hills" being superficial or otherwise, it will be well to state what I regard as evidence of a rock being superficial. When the boundary of a rock is of an irregular kind, like the outline of a map, and is surrounded on all sides by other rocks which have a more definite strike, particularly if its boundary is nearly horizontal and follows approximately the contours of the present valleys, I take it to be superficial. In proportion, of course, as these features are wanting, the evidence is less satisfactory. They are all fulfilled by the grit on Caidington Hill. I am not at all sure that Dr. Callaway has seen this patch, for the rock which composes it is *not* like the Woodgate quarry rock. As to Charlton Hill, Dr. Callaway gives a section, but this section is not seen, but inferred. The map I give is what is actually *seen*, and this proves the inference to be wrong. I am sorry to say that this map, on p. 410, is so small that it requires a lens to examine it. Small circles on it indicate exposures, and the boundary lines are drawn to include exposures of similar rock. Let Dr. Callaway show that this is wrong. It is drawn carefully to scale on the One-inch Ordnance Map, and there cannot be the slightest difficulty in knowing the exact spots intended. The same remark will apply to the two patches of igneous rock "near the south-eastern end of the Wrekin," as to which he says he is in the dark; a lens will show him *exactly* where they are on the One-inch Map.

On the crystalline rock of the Ercal, it will be sufficient to compare the two following passages: "Prof. Bonney said the rhyolite was clearly intrusive in the granitoid series" (Q.J.G.S. 1879, p. 669). "He" (Prof. Bonney) "cannot find any distinct proof of the intrusion of the felsite in the granite" (Q.J.G.S. 1891, p. 118).

Finally, with regard to the difference in strike of the rocks of the Volcanic Hills and the Longmynd rocks, it does not appear to me to be of any great consequence, and in any case does not prove the former to be older. Many of the rocks in the former have no strike at all, and the strikes noticed are very variable. Volcanic rocks, even when clastic, are apt originally to have a quâquâversal dip, and more than all, the rocks on the east side of the great fault have had to bear the brunt of all the earth-movements, and they have yielded to them in no simple way.

The third paper I wish to speak of is by Miss Raisin, "On the Lower Limit of the Cambrian Series in N.W. Carnarvonshire." This I have only here to refer to as it deals with supposed *Precambrian* rocks. One general observation is necessary. The authoress continually speaks of my conclusions as "new." They are in fact essentially the conclusions of Sir A. Ramsay, and the only novelty about them is the reconciliation of these with *some portion* of the more recent conclusions of other writers.

The proofs which I gave of the general correctness of Sir A. Ramsay's conclusion Miss Raisin has sought to invalidate, and in one case I have now to acknowledge she has done so with success. On re-visiting Bryn-Efail I find that her reading of the section is the true one, and my own is erroneous. I would make this acknowledgment in any case, but I do it now with all the more readiness, that I find that the mistake is an entirely gratuitous one. If my reading had been correct, it would have constituted a difficulty, rather than an aid in the true reading of the district.

The fact is, that when I wrote my paper I was studying Precambrian rocks, and as soon as I found that there were none in the district—for the proof of which the other observations are amply sufficient, and had led me to this conclusion before ever I saw Bryn-Efail—I grudged any more time for the subject, and was glad of a short cut, which has proved to be disastrous. I saw that to understand the real history of these volcanic masses involved a survey of the whole of the Cambrian rocks of the district—a task from which I shrank. That survey I have, however, now made, and hope shortly to present the results. By this I have learnt, that a great number of previous supposed results, some of my own among them, are entirely wide of the mark. The only thing that becomes clearer than ever is that there are no stratified Precambrian rocks in the ordinary sense in North-West Carnarvonshire. These results will render it useless to reply to any other points in Miss Raisin's paper.

III.—A MINIATURE ILLUSTRATION OF NORMAL FAULTING.

By T. MELLARD READE, C.E., F.G.S.

WHEN examining the Glacial drift at Nevin, Carnarvonshire, I observed in a banded silty clay occupying the top of the cliff of drift at a point between Porth Nevin and Porth Bodeilias, an excellent illustration of my theory of Normal Faulting.[1]

The bed in question consisted of an extremely finely laminated silty clay, sometimes called book-leaf clay, the laminations being grouped in ribands about half an inch wide and six inches apart, of lighter and darker colours, presenting a striped appearance very conspicuous from the shore. In the upper part of the bed the bands were continuous, though a little wavy: the lower part of the bed, as far as it was visible above the talus of sand, was faulted as shown in the accompanying diagram (Fig. 1). These faults simulated in a remarkable manner sections of faulted coal-fields which have been drawn from actual mining exploration and measurement. The greatest throw was 3½ inches measured on the hade of the fault. Almost every feature of Normal Faulting was reproduced in miniature by this natural diagram, among which are the dropping of the wedge-shaped blocks (as at *e*, Fig. 1); the universal hade to the downthrow; the occasional curve of the beds (bands) downwards on one side and upwards on the other as at *fff*, the result of slipping and the tight fitting together of all the parts or wedges into which the strata have been divided by shearing.

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[1] Chap. viii. Origin of Mountain Ranges.

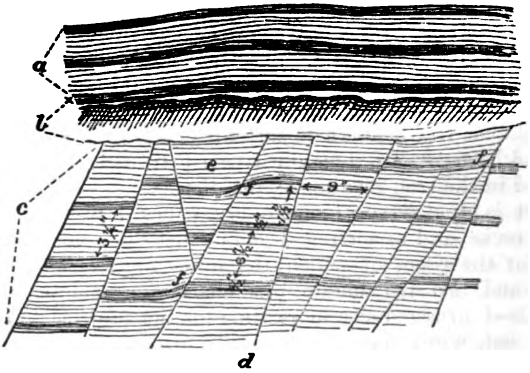

Fig. 1.—Section of faulted laminated silty clay as exposed in the Cliffs of Glacial Drift at Nevin, Carnarvonshire. Scale ½ inch to a foot (a portion only.)
a. Banded laminated silty clay (unfaulted).
b. Cavity, the underside at × studded with hardened guttæ of sand,—the cavity in part being filled with sand.
c. Similar banded clay to *a*, but faulted as shown.
d. Talus of sand below this.

It is evident that the faulting of these banded beds is due to their contraction and loss of volume, either by actual drying or by the draining away of their water. Between the overlying unfaulted bed (*a*) and the faulted bed (*c*) there was a cavity at (*b*) six inches wide at the widest part. On the bottom or underside of the unfaulted bed at × were "guttæ" or drops of hardened sand, the underside looking as if studded with petrified raindrops. Probably this cavity was formerly a thin bed of sand which allowed the surface water percolating through the upper bed to drain away without affecting the lower bed. It is not easy to trace the exact *modus operandi* of Nature in this case, as observation was difficult from the insecure foothold on the sand talus at *d*.

An examination of the constitution of this laminated silt by breaking up six ounces of it in water and riddling it showed that a few grains of sand only were caught in a mesh of $\frac{1}{40}$ of an inch, and 10 grains by weight of sand in a mesh $\frac{1}{100}$ of an inch. All the rest passed through the $\frac{1}{100}$ inch mesh and ¾ oz. and 10 grs. were caught by precipitation.

The portion that flowed away without precipitation must have consisted largely of very small granules, probably of quartz, for the silty clay when dry rubs on to the fingers like flour. This peculiar constitution, together with the fine sandy laminations at which the clay readily separated, rendered the material very "short" on drying, facilitating its rupture by shearing and the keying up of its divided portion by wedging, on the principle known to mechanics as "fox wedging." If the bands were replaced in their original position, they would not fill up the gap. The material must shrink a good deal in drying.

If we substitute volumetrical-contraction by change of temperature for contraction by loss of moisture, and increase the size, weight, and rigidity of the beds, we have at once my theory of Normal Faulting, as explained in chapter viii. of the Origin of Mountain Ranges. It is certainly remarkable how the material gets repacked by shearing and wedging up, even in such miniature faultings as are here described. There are absolutely no cavities, the faults being mere lines, so close do the constituent parts fit each other. No doubt Nature reproduces great faulting in this miniature manner through the small shearing strength of the beds. Had there been more clay in the material, it would have proved too plastic for the purpose. In the actual faulting of the earth's crust the weight of the rock is much greater in proportion to the shearing stress brought into play by contraction.

In conclusion I ask, as a suggestion for the consideration of those who have studied the subject, whether the minute faults sometimes found in banded slates have not been produced in somewhat the same manner.[1] It certainly seems clear to me that the faulting in such cases has preceded the cleavage.

IV.—ON THE AMOUNT OF SAND BROUGHT UP BY LOBWORMS TO THE SURFACE.

By CHARLES DAVISON, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

TEN years ago Charles Darwin published his last work,[2] the result of more than forty years' observations on the habits of earthworms and the rate at which they bring up soil to the surface. To ascertain this rate, he made use of two methods. In the first place he measured the rate at which layers of lime or cinders were covered over by the spread-out castings of worms; and, later, he collected and weighed all the castings thrown up over a definite area within a given time. As is well known, the general result of his investigation was greatly to exalt our ideas of the importance of earthworms and of the work they do upon the surface of the land.

The work performed by lobworms on the surface of tidal sands seeming not less worthy of study, I made some observations on the subject during a short stay in Holy Island last August. Between this island and the opposite coast of Northumberland is an expanse of sand (called the Holy Island Sands) about three miles wide, which is laid bare by the sea a few hours after high-water, and is then seen to be thickly studded with castings formed by lobworms. In any one spot, the castings seem to be scattered with a fair approach to uniformity, but patches of sand, apparently not differing from the rest, occur in places without any castings. When the surface is covered with broken shells, they are also rare or altogether absent, unless the sand is much ripple-marked, and then the shells collect in the hollows, while castings are common on the intervening ridges. A few observations were also made in the two bays on the north side of the island, but here the beach is more exposed, and consequently the castings, though hardly less numerous, had lost more from the action of the rougher sea.

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[1] See "A Faulted Slate" by J. J. Harris Teall, GEOL. MAG. 1884, pp. 1, 2.

[2] "The Formation of Vegetable Mould, through the action of Worms, with Observations on their Habits," 1881.

It will be obvious that the second, but more accurate, of Mr. Darwin's methods was the only one that could be followed with profit in the present case. In several places where the castings were uniformly scattered, I marked off spaces bounded by straight lines, some of them roughly square, but the majority triangular in form. Within these spaces I counted all the castings that had been thrown up, with one exception, either about or after the time of low-tide, and from six of them filled wide-mouthed jars with castings, which were afterwards thoroughly dried and weighed.

Number of castings in a given area.—On the Holy Island Sands, I counted the number of castings in nineteen measured areas, all but one within the square mile, bounded on two sides by the Snook and the west coast of the island. The smallest of these areas contained 2,679 square inches, the largest 17,278; the average being 6,268 square inches, or a little less than five square yards. In order to compare the results with one another, and with those given by Mr. Darwin, I have calculated in each case the equivalent number of castings per acre. The smallest number so found is 39,935, the largest 203,272. In both these cases the castings were fairly large. In two other areas, where the castings were the largest I have seen, the numbers are 52,568 and 70,372. Taking all the 19 areas together, *the average number of castings is* 82,423 *per acre*, or more than fifty million per square mile.

On the north coast of the island there are two bays in which patches of sand occur. In each of these I counted the number of castings in three measured areas, but the numbers here given may be too small, for the castings had obviously lost much by the rougher sea, and it is possible that some were altogether obliterated. In Caves Haven, the more westerly of the two bays, the average area measured was 10,162 square inches; and the numbers of castings per acre were 86,344, 75,345 and 50,036, the average of these being 70,575 per acre. In the other bay, that to the west of Emanuel Head, the average area measured was 5,714 square inches, and the numbers of castings per acre 227,177, 65,584 and 62,114, the average being 94,466 per acre. The castings in the first of the last three areas were however small.

Weight of the castings in a given area.—Castings were collected from four areas on the Holy Island Sands with the following results:—

(1) About 100 yards from the Holy Island shore and nearly opposite the village, a triangular area of 13,534 square inches was measured off. It contained 87 castings, equivalent to 40,322 per acre. Sixteen of these were collected; their total weight when dried was 7,955 grains, *i.e.* an average of 497 grains or about 1⅛ oz. for each casting. Now, the number of high tides in the year is 705. Hence, if the same number of castings are formed every day throughout the year,[1] the total weight of castings thrown up annually would be 901 tons per acre.

(2) About 100 yards from the shore and nearly opposite the old lime-kilns, an area of 6,324 square inches contained 53 castings, *i.e.* at the rate of 52 568 per acre. These castings were all large. Six of them weighed 7,986 grains, or on an average 1,331 grains or about 3 oz. each. The total weight thrown up annually would thus be 3,146 tons per acre.

(3) About 100 yards N.W. of the last place and the same distance from the shore, an area of 7,844 square inches contained 88 castings, equivalent to 70,372 per acre. All of these castings were large. Seven of them weighed 6,963 grains, *i.e.* an average of 995 grains or about 2¼ oz. each. At this rate, the weight of sand brought up annually would be 3,147 tons per acre.

(4) About one mile N.W. of the village and a quarter of a mile from the shore, an area of 5,304 square inches contained 38 castings, or 44,941 per acre. These castings were very much smaller than are usually found on the Holy Island Sands, and only about half the average number per acre. Twenty of them weighed 4,444 grains, *i.e.* an average of 222 grains or about half an ounce each; giving a total weight ejected annually of 449 tons per acre.

Taking the average of these four estimates, we find that *the amount of sand brought up to the surface by lobworms every year is* 1,911 *tons per acre.*[2] But this is probably less than the actual amount; for, though the castings in the second and third areas were larger than usual, yet in the fourth they were much below the average size, and in every case the number of castings per acre was less, and in two cases much less, than the average number formed on the Holy Island Sands.

On the north side of the island, in Caves Haven, castings were collected from two places:

(5) An area of 12,568 square inches contained 173 castings, equivalent to 86,344 per acre. Sixty of these castings weighed

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[1] I have not been able to learn anything decisive on this point, but I was informed by a resident on Holy Island that the castings appeared to be quite as numerous there in winter as in summer.

[2] Mr. Darwin has calculated the amount of soil brought up by earthworms in four cases, one of these being near Nice and the other three in England. The results are 14·58, 18·12, 7·56, and 16·1 tons per acre every year (pp. 160–169). The average of these estimates being 14·09 tons per acre, it follows that the weight of sand brought up by lobworms is 136 times the weight of soil brought up by earthworms over an equal area in the same time.

6,119 grains; or, on an average, 102 grains or about a quarter of an ounce each. At this rate the total weight of sand brought up annually would be 396 tons per acre.

(6) An area of 13,154 square inches contained 158 castings, equivalent to 75,345 per acre. Sixty of them weighed 5,835 grains, *i.e.* an average of 97 grains or less than a quarter of an ounce for each casting. The total weight of sand brought up annually would thus amount to 329 tons per acre.

The average of these two estimates is 363 tons per acre, less than one-fifth of the average for the Holy Island Sands. But it must be much less than the amount of sand actually brought up, for the castings in Caves Haven had evidently suffered considerable degradation and some may have entirely disappeared.

Volume of sand spread over a given area.—After the sand from each of the six areas had been thoroughly dried and weighed, it was placed in a measuring-glass and pressed firmly down, in order to determine roughly the volume of sand brought up annually over an acre. The results are given in the following table:—

	Volume of castings collected. c. ins.	Volume of sand brought up annually per acre. c. ft.	Thickness of the layer of sand brought up ann. ins.
(1) Holy Island Sands	20·93	21,522	5 93
(2) „ „	20·99	80,815	22·26
(3) „ „	18·43	75,591	20 82
(4) „ „	12·02	11,022	3·04
(5) Caves Haven	16 48	9,670	2·66
(6) „	15·99	8,192	2·26

On the Holy Island Sands, therefore, the average volume of sand ejected by lobworms every year is 47,237 c. ft. per acre, and the average thickness of the layer formed by it is 13 inches. In Caves Haven, the average volume of sand ejected annually is 8,931 c. ft. per acre, and the average thickness of the layer formed by it is 2½ inches.

Now, according to Carpenter, the depth to which lobworms burrow is from 12 to 18 inches, and according to Johnston about two feet.[1] Taking the higher of these two estimates, it follows that, in the Holy Island Sands, the layer of sand in which the lobworms live must on an average pass through their bodies once in 22 months.

Geological work of Lobworms.—The figures above given will show, I think, how important is the work accomplished by lobworms. We have seen that over an acre nearly two thousand tons of sand are brought up by them in the course of a year and deposited on the surface. Of course, the distance through which it is carried is not great; but, unlike most other agents of geological change, it is carried in the direction opposite to that in which gravity acts. The uppermost layer of sand must frequently pass through the bodies of lobworms, and in this way the sand-particles must become slightly worn. But this is of small importance compared with the fact that fresh sand is being continually introduced by them to the rounding action of the waves.

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[1] Dr. W. B. Carpenter, "Zoology" (1867), vol. ii. p. 300. Dr. G. Johnston, "A Catalogue of the British Non-parasitical Worms in the Collection of the British Museum" (1865), p. 230.

Nearly all castings are formed on a surface of sand which is inclined towards the sea. At the first touch of the water, a casting sinks down and swells out at the base, and more of the casting flows down the slope than up it. This flowing was especially marked at one spot on the Holy Island Sands, where the beach was slightly inclined and the surface discoloured by mud. The castings formed on it were composed of clean sand, and had evidently been surrounded by one or several waves as the tide went down. We cannot always be certain that the summit of a casting was originally above its centre, but in every one by far the greater part of the spread-out base lay below the highest point of the casting. In some cases, the castings had entirely lost their vermiform appearance, and were simply long low mounds, the longer axes pointing down the slope. In others, they had flowed so much that they could only be distinguished by their different colour from the surrounding sand.

V.—NOTE ON THE OCCURRENCE OF *AMMONITES JURENSIS* IN THE IRONSTONE OF THE NORTHAMPTON SANDS IN THE NEIGHBOURHOOD OF NORTHAMPTON.

By E. T. NEWTON, F.G.S.

CONSIDERABLE doubt having been expressed with regard to the occurrence of the zone of *Ammonites jurensis* in the neighbourhood of Northampton, much interest attaches to the discovery, by Mr. T. Jesson of Great Houghton, of the typical Ammonite in some abundance in this area. It is perhaps remarkable that there should have been any doubt about the matter, seeing that in Samuel Sharp's earlier paper[1] *Am. jurensis* was recorded among the fossils from Duston, and this should have stimulated further search when the doubt arose which seems to have caused this species to be omitted from the later paper by the same author,[2] in which some palæontological errors of the earlier paper were said to be corrected. This omission led subsequent writers to think that *Am. jurensis* did not occur in the neighbourhood, and, indeed, it does not appear to have been met with by other workers in the district until the present discovery by Mr. Jesson.

In 1874 Mr. Sharp conducted an excursion of the Geologists' Association to Northampton, and in the report of that excursion Mr. W. H. Hudleston[3] notices the section of the "ironstone series of the 'Northampton Sand'" at Duston Quarries, but does not mention *Am. jurensis* as being among the fossils found.

Mr. Beeby Thompson, in his paper on the "Upper Lias of Northamptonshire,"[4] maintains that the *Am. jurensis* zone is represented in the clayey series beneath the Northampton Ironstone, by his "Upper *Leda-ovum* beds," although the characteristic *Ammonite* had not been found; this view, however, has been contested by Mr. S. S. Buckman in a later number of the same journal.

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[1] Q J.G.S. vol. xxvi. p. 354, 1870.

[2] Q.J.G.S. vol. xxix. p. 296, 1873.

[3] Record of Excursions, London, 1891, p. 452.

[4] Journ. Northamptonshire Nat. Hist. Soc. vol. v. p. 54, 1888.

Mr. Jesson, who has been for some time collecting assiduously from the Ironstone beds in the neighbourhood of Northampton, has been kind enough to send to the Museum of Practical Geology, for examination, the series of specimens which he has obtained. These are chiefly *Ammonites*, some being from Duston, but the greater number are from Brixworth, about seven miles N. of Northampton. The species which have been determined are given in the list below, but by far the greater number of specimens from the last-named locality are referable to the two species *Am. jurensis* and *Am. opalinus*, which are about equally numerous, while each of the other species is represented by only two or three specimens. The examples which are referred to *Am. jurensis* are very uniform in character, allowance being made for variation in size; some of the smaller (which may be the middle portions of larger ones) being an inch or so in diameter, while others measure as much as six or eight inches, and there are fragments of one specimen which must have been at least 15 inches in diameter, or somewhat larger than the example in the Museum of Practical Geology, figured half its natural size by Dr. Wright,[1] with which these Brixworth Ammonites exactly agree.

The specimens which are referred to *Am. opalinus* correspond with those figured by Mr. S. S. Buckman.[2] *Am. insignis* is represented by two or three specimens in which the tubercles near the inner margin are large, and in one example (4 or 5 inches in diameter) almost obsolete. Another example has better defined tubercles, until the Ammonite is about 5 or 6 inches in diameter, but the outer whorl, which, if perfect, would be perhaps 10 inches in diameter, is nearly smooth, having almost lost both ribs and tubercles. Two or three examples of a variety of *Am. insignis* are included in this collection, which agree with that figured by Dr. Wright[3] as an abnormal young specimen.

The occurrence of *Am. jurensis*, *insignis*, *opalinus*, and *Murchisonæ* in the Northampton Ironstone would seem to indicate that the *Ammonite* zones are not so sharply defined in this area as they are considered to be in some localities in the southern and western counties; it is possible that future investigation may show the ironstone series to be divisible into definite horizons, but at present we have no evidence as to the particular part of the ironstone series from which the fossils have been derived.[4]

FOSSILS FROM THE IRONSTONE OF BRIXWORTH.

Ammonites jurensis.
,, *opalinus.*
,, *insignis.*
,, ,, var.
,, *Murchisonæ.*

Nautilus sp.
Belemnites sp.
Trigonia compta.
,, *v. scripta.*
Tancredia axiniformis?

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[1] Pal. Soc., Lias Ammonites, pl. lxxix.

[2] Pal. Soc. Inferior Oolite Ammonites, pl. xiii.

[3] Pal. Soc. Lias Ammonites, pl. lxxv. figs 1–3.

[4] This paper was read in Section (C) Geology, Brit. Assoc. Cardiff, Aug. 1891.

VI.—ON *ATHYRIS LÆVIUSCULA*, SOW., SP., WITH THE FULL DISCLOSURE OF ITS LOOP, ETC.

By the Rev. NORMAN GLASS.

DAVIDSON thus describes the external characters of this species in his Sil. Suppl. pp. 101, 102. The description is practically the same as that which he previously gave in his Sil. Mon. "Marginally of a somewhat elongated, pentagonal shape, truncated, and slightly indented in front, broadest about the middle. Tapering posteriorly. Valves almost equally convex, with a slight median depression near the front in the ventral valve. Beak strongly incurved, and truncated by a minute oval foramen; surface smooth, marked by a few concentric lines of growth. Length 6, breadth 5 lines, but the generality of specimens are much smaller." Davidson refers to the spirals of this species both in his Sil. Mon. and in his Sil. Suppl. Sil. Mon. p. 115: "I had noticed the presence of spirals in 1847, and recorded the observation in the 'Bulletin Soc. Géol. France,' and Lindström has also detected them in a Gothland specimen." In pl. x. fig. 31 of his Sil. Mon. Davidson represents the dorsal aspect of the spirals, with the bases of the spirals facing each other in the centre of the shell. The spirals of this species are more fully referred to in Davidson, Sil. Suppl. p. 102: "The small dimensions attained by this species caused the Rev. Norman Glass much trouble in his patient endeavours to work out its interior arrangements. A great number of English specimens were operated upon, as well as a number of Swedish ones kindly contributed by Prof. Lindström of Stockholm. Mr. Glass has shown in a very plain manner the accessory lamellæ, also the hook-shaped attachments to the hinge-plate; but, on account of the smallness of the specimens, it was not possible to expose the loop or its attachments to the primary lamellæ in the same manner as he had so successfully achieved in *Athyris plano-sulcata.* We are both convinced that Sowerby's species is an *Athyris.* In a specimen one line and a half in length cleared out by Mr. Glass, there were only three coils in each spiral. In another four lines in length, four coils; and none of the largest specimens have shown more than six or seven in each spiral." In his Sil. Suppl. pl. iv. figs. 25, 26, Davidson gives representations of the dorsal and ventral aspects of the spirals—the ventral aspect including the hook-shaped attachments of the primary lamellæ to the hinge-plate and the accessory lamellæ of the loop.

Davidson in the above quotation credits me with a stronger impression than I possessed as to this species being an *Athyris.* Certainly so far as the hook-shaped attachments of the primary lamellæ to the hinge-plate were concerned, and the ventral aspect of the accessory lamellæ, there was nothing to distinguish this species from *Athyris,* but in *Athyris* the accessory lamellæ are continued over the posterior border and about half-way down the dorsal side of the spirals, and no evidence of this had been discovered when the Sil. Suppl. was published—indeed those preparations which I had sent to Davidson showing the dorsal aspect of the spirals exhibited no trace of this extension of the accessory lamellæ. Besides, it was evidently impossible to decide with any certainty that this species was an *Athyris* whilst the loop and its attachments to the primary lamellæ were undiscovered.

Davidson in his Sil. Mon. described three species of *Athyris*, namely *Athyris obovata*, *A. compressa*, and *A. depressa*—the latter marked by a sign of interrogation. Through his further study, however, and through my own researches, he afterwards in his Sil. Suppl. withdrew the whole of these from the generic denomination of *Athyris*. *Athyris obovata* and *A. compressa* he determined as being nothing more than modifications in shape of a single species referable to his new genus of *Glassia*, and in his Sil. Suppl. p. 155, he made the following statement as to *Athyris depressa*:—"The Rev. N. Glass was able to develop the interior, and to clear away all uncertainty as to the generic position of the shell, for it has the two short, curved lamellæ of the genus *Rhynchonella*." As therefore the only known representative left of the genus *Athyris* in the British Silurian rocks, according to Davidson in his Sil. Suppl., was *Athyris læviuscula*, and as I had many doubts at to its real generic position, I determined to avail myself of every opportunity for further investigation. And now, after the lapse of nearly ten years, and after many unsuccessful efforts to procure suitable specimens, I have at last been enabled fully and decisively to reveal the loop of this species, and thereby conclusively to prove that it cannot possibly be regarded as belonging to the genus *Athyris*.

I have to express my thanks to G. H. Maw, Esq., Benthall Works, Jackfield, Shropshire, for his great kindness in sending to me about one cwt. of blunged material from the exposure of the Tickwood beds, by the side of a small stream flowing down the east end of Benthal Edge, opposite Ironbridge. This material I found on further washing to consist of thousands of small pieces of hard rock, innumerable fragments of Corals and Encrinites, many small specimens of *Spirifera*, *Rhynchonella*, *Nucleospira*, etc., and above all a goodly number of the species for which I had been so long in search.

The following descriptions of the loop of *Athyris læviuscula*, and of the median septum in the dorsal valve which has hitherto been undiscovered, are based upon a number of my preparations, some of them very minute, and others from four to five lines in length.

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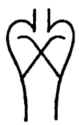

Ventral aspect of the loop of *Athyris læviuscula*, Sow., sp.

The loop of *Athyris læviuscula* commences from the dorsal side of the spirals slightly above their centre, and consists of two short converging lamellæ, which arise from the primary lamellæ, and which proceed in an upward and sloping direction between the spirals and right across to their ventral side before uniting in a sharp point beneath the hook-shaped attachments to the hinge-plate. Arising from this uniting point of the loop there is a bifurcation—the two accessory lamellæ thus formed curving in an upward and backward direction to the posterior border of the spiral. (In the accompanying sketch the primary lamellæ and their hook-shaped attachments to the hinge-plate are shown denuded of the rest of the spirals. For similar figs. of my preparations of *Whitfieldia tumida vide* Davidson, Silurian Supplement, plate vi.)

The differences between the loop of this species and that of *Athyris* are thus very strongly marked. 1. Between the simple V-shaped commencement of the loop and the bifurcation there is in *Athyris læviuscula* no roof-shaped expansion and single lamella as in the true *Athyris.* 2. The short, converging processes which commence the loop in *Athyris læviuscula* at once proceed in an upward direction—whereas in the true *Athyris* they proceed first in a slightly downward direction before uniting to form the roof-shaped expansion. 3. The accessory lamellæ at the end of the loop in *Athyris læviuscula* do not extend beyond the posterior border of the spirals, and are not prolonged down a portion of the dorsal side of the spirals as in the true *Athyris.*

I may mention here that there is a median septum supporting the hinge-plate in the dorsal valve of *Athyris læviuscula* similar to that which is found in *Whitfieldia tumida.* This median septum extends to a little more than one-third of the length of the shell, and is in some cases visible when the shell is transparent. In addition, however, to this evidence I have clearly proved the existence of the median septum in *Athyris læviuscula* by rubbing down the umbo of the dorsal valve in a rather large specimen. In this specimen the shell is destitute of spirals and filled with a light earthy matrix in which the darker coloured median septum is very apparent. When describing *Meristella* [*Whitfieldia*] *tumida* in his Sil. Mon. p. 110, Davidson refers to the median septum of its dorsal valve as being visible through the transparent shell, and in his Sil. Suppl. pl. iv. fig. 24, he represents a similar appearance in *Athyris læviuscula,* and yet he makes no reference to the median septum in this species, and does not seem to have been aware of its existence.

Sowerby's *læviuscula,* according to Davidson, has had a remarkable history so far as the generic positions assigned to it are concerned. After variously figuring in the works of Sowerby, Hall, Bronn, De Verneuil, D'Orbigny, Salter, Lindström and Davidson, as *Terebratula, Atrypa, Rhynchonella, Meristella, Meristina, Spirigera,* and *Athyris,* I think this species must now after full investigation be finally placed under Davidson's more recent genus of *Bifida—vide* Davidson, Devonian Supplement, pp. 27, 28.

Both in *Bifida lepida* and in Sowerby's *læviuscula* the simple V-shaped commencement of the loop is immediately succeeded by the bifurcation without any intervention of a roof-shaped expansion and single lamella as in *Athyris,* or of a single lamella as in *Kayseria* and *Whitfieldia.* Davidson, in his Sil. Suppl., evidently regarded the spirals and their connexions as the principal if not the sole ground for the determination of the different genera of the spiral-bearing Brachiopoda. Thus, where it was found on investigation that the spirals and loop in several different genera were in all important respects the same, he was evidently inclined to class the whole of these genera under one generic denomination, despite their marked and manifold external differences. In his Sil. Suppl. p. 95, he says: "It will remain a question for further consideration whether we are justified in retaining the three generic denominations of *Nucleospira*, *Retzia*, and *Meristina*, for shells possessing the same simple loop." It is therefore in agreement with the principles of classification adopted by Davidson that I now place the species which Sowerby named *læviuscula* under the genus *Bifida*, of which *Bifida lepida* is the type.

P.S.—Davidson's Sil. Suppl. was issued in two portions in the Annual volumes of the Palæontographical Society for 1882 and 1883. After writing the above article I have found in the Index accompanying the latter portion of the Suppl. that Davidson ultimately had the same doubts as myself as to the true generic position of *læviuscula*. In the Index referred to—Sil. Suppl. p. 233—Davidson puts a note of interrogation to the generic name of *Athyris* as applied to *læviuscula*, and he adds concerning *Athyris*,—"It is not certain whether we possess any true British Silurian species of the genus."

NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE SECTION C. AT BRITISH ASSOCIATION MEETING, CARDIFF, August, 1891.

I.—DISCOVERY OF THE OLENELLUS-ZONE IN THE NORTH-WEST HIGHLANDS. By Sir ARCHIBALD GEIKIE, F.R.S., Director-General of the Geological Survey.

EVER since the Geological Survey began the detailed investigation of the structure of the North-west Highlands of Scotland the attention of its officers has been continuously given to the detection of any fossil evidence that would more clearly fix the geological horizons of the various sedimentary formations which overlie the Lewisian gneiss. A large collection of organic remains has been made from the Durness Limestone, but it has not yet yielded materials for a satisfactory stratigraphical correlation. The study of this collection, however, has confirmed and extended Salter's original sagacious inference that the fauna of the Durness Limestone shows a marked North American facies, though, according to our present terminology, we place this fauna in the Cambrian rather than in the Silurian system. Below the Durness Limestone lies the dolomitic and calcareous shaly group known as the 'Fucoid beds,' which, though crowded with worm-castings, has hitherto proved singularly devoid of other recognizable organic remains. In following this group southwards through the Dundonnell Forest, in the west of Ross-shire, my colleague, Mr. John Horne, found that, a few feet below where its upper limit is marked by the persistent band of 'Serpulite grit,' it includes a zone of blue or almost black shales, During a recent visit to him on his ground, when he pointed out to me this remarkable zone, I was struck with the singularly unaltered character of these shales, and agreed with him that, if fossils were to be looked for anywhere among those ancient rocks, they should be found here, and that the fossil collector, Mr. Arthur Macconochie, should be directed to search the locality with great care. The following week this exhaustive search was undertaken, and Mr. Macconochie was soon rewarded by the discovery of a number of fragmentary fossils, among which Mr. B. N. Peach, who was also stationed in the district, recognized what appeared to him to be undoubtedly portions of *Olenellus*. The importance of this discovery being obvious, the search was prosecuted vigorously, until the fossiliferous band could not be followed further without quarrying operations, which in that remote and sparsely inhabited region could not be at that time undertaken. The specimens were at once forwarded to me, and were placed in the hands of Messrs. Sharman and Newton, Palæontologists of the Geological Survey, who confirmed the reference to *Olenellus*. More recently Mr. Peach and Mr. Horne, in a renewed examination of the ground, have found, in another thin seam of black shale interleaved in the 'Serpulite grit,' additional pieces of *Olenellus*, including a fine head-shield with eyes complete. There may be more than one species of this Trilobite in these Ross-shire shales. The specific determinations and descriptions will shortly be given by Mr. Peach.

The detection of *Olenellus* among the rocks of the North-west Highlands, and its association with the abundant *Salterella* of the 'Serpulite grit,' afford valuable materials for comparison with the oldest Palæozoic rocks of other regions, particularly of North America. The 'Fucoid beds' and 'Serpulite grit' which intervene between the quartzite below and the Durness Limestone above are now demonstrated to belong to the lowest part of the Cambrian system. The quartzites are shown to form the arenaceous base of that system, while the Durness Limestones may be Middle or Upper Cambrian. On the other hand, the Torridon Sandstone, which Murchison placed in the Cambrian series, can now be proved to be of still higher antiquity. The marked unconformability which intervenes between it and the overlying quartzite points to a long interval having elapsed between the deposition of the two discordant formations. The Torridon Sandstone must therefore be pre-Cambrian. Among the 8,000 or 10,000 feet of strata in this group of sandstones and conglomerates, there occur, especially towards the base and the top, bands of grey and dark shales, so little altered that they may be confidently expected somewhere to yield recognizable fossils. Already my colleagues have detected traces of annelids and some more obscure remains of other organisms in these strata. These, the oldest relics of life yet known, have excited a vivid desire in the Geological Survey to discover further and more determinable fossils associated with them in the same primeval resting-place. We shall spare no pains to bring to light all that can be recovered in the North-west Highlands of a pre-Cambrian fauna.

II.—A COMPARISON BETWEEN THE ROCKS OF SOUTH PEMBROKESHIRE AND THOSE OF NORTH DEVON. By HENRY HICKS, M.D., F.R.S., Sec. Geol. Soc.

THE clear succession from the Silurian rocks to the Carboniferous to be observed in many sections in South Pembrokeshire offers, in the author's opinion, the key to the true interpretation of the succession in the rocks of North Devon, for there cannot be a doubt that the post-Carboniferous earth-movements which so powerfully affected and folded the beds in North Devon extended into and produced almost identical results in South Pembrokeshire. In the latter area, however, the succession remains clearer, and can be traced more continuously.

The base of the Silurian (Upper Silurian Survey) is exposed at many points, and the lower beds repose transgressively on the Ordovician, and even on some pre-Cambrian rocks. Near Johnston and Stoney Slade the conglomerate contains numerous pebbles of the Johnston and Great Hill granite as well as of other igneous masses which were formerly supposed to have been intrusive in these beds. From the Silurian to the Carboniferous beds there does not appear to be any marked break in the series; moreover, all these beds were folded together and suffered equally by the movements which affected the area. The axes of the folds strike from about W.N.W. to E.S.E. The movements, therefore, at this time were in a nearly opposite direction to those which affected the Ordovician and Cambrian rocks at the close of the Ordovician period. Within the broken anticlinal folds portions of the old land surfaces have been exposed in several places by denudation.

The succession exposed in this area and the effects produced by the earth-movements so nearly resemble those already described by the author as occurring in North Devon, that he is convinced that the beds must have been deposited contemporaneously in one continuous subsiding area, and that the differences recognizable are chiefly in the basal beds, which were deposited on an uneven land surface.

III.—ON THE EVIDENCES OF GLACIAL ACTION IN PEMBROKESHIRE, AND THE DIRECTION OF ICE-FLOW. By HENRY HICKS, M.D., F.R.S., Sec. Geol. Soc.

THE occurrence of ice-scratched rocks and of northern erratics in North-west Pembrokeshire has already been mentioned by the author, but in this paper he brings forward additional evidence to show that, during the Glacial period, a great thickness of land-ice must have passed over Pembrokeshire.

The glacial striæ, which are so well preserved under the drift along the north-west coast, especially at Whitesand Bay, show that the ice travelled over that area mainly from a north-western direction. The presence of erratics from North Wales and from Ireland would tend to the conclusion that glaciers from these areas coalesced in St. George's Channel, and that the ice which overspread Pembrokeshire was derived from both these sources, as well, probably, as from a flow extending down the channel from more northern areas.

Although there are in the district many northern erratics, notably a large boulder of granite and another of picrite, which the author found on Porthlisky farm, two miles south-west of St. David's, yet by far the majority are of local origin, and can be traced back to the parent rocks. The great igneous masses which now form such conspicuous hills along the north coast yielded most of the boulders, many of very large size, which are so freely spread over the undulating land reaching to the coast of St. Bride's Bay. There are clear evidences to show that this bay was itself overspread by a great thickness of drift from these hills. The intervening preglacial valleys were also filled by this drift, and the plains and rising grounds up to heights of between 300 and 400 feet still retain evidences of its former presence, and many perched blocks. Excellent sections of unstratified drift, containing large ice-scratched boulders, are exposed in Whitesand Bay, and a thickness of several feet of an irregularly stratified sand was, some time since, exposed under the Boulder-clay on the east side of the bay. Chalk flints have been found at heights of over 300 feet, having probably been brought from Ireland. The picrite boulder already referred to has been shown by Prof. Bonney to resemble masses of that rock exposed in Carnarvonshire and Anglesea, and the granite boulder, which before it was broken must have been over 7 feet in length and 3 to 4 feet in thickness, is identical with a porphyritic granite exposed in Anglesea, but not found anywhere in Pembrokeshire. The evidences, therefore, which go to prove that Pembrokeshire was buried under an ice-sheet that must have spread southwards into the Bristol Channel, are, the presence of many northern erratics, both as perched blocks and in drifts at heights above 300 feet, ice-scratched, smoothed and polished rock surfaces, and, in places, much crushing and bending of some of the strata; also great dispersions of boulders from igneous rocks on the north coast in a south-west direction, and some well-marked examples of 'crag and tail.'

IV.—NOTES UPON *COLOBODUS*, A GENUS OF MESOZOIC FOSSIL FISHES.

By MONTAGU BROWNE, F.Z.S., F.G.S.

COLOBODUS appears to have been first constituted a genus in the year 1837 by Louis Agassiz (see 'Poissons Fossiles,' Tome II., ii^e partie, p. 237), who gave this name to some *Lepidotus*-like teeth (*Colobodus hogardi*) from the Muschelkalk, which he described thus:—"Par leur taille elles tiennent le milieu entre les Microdon et les Sphærodus. De formes arrondies et cylindracées vers la base, les dents ont leur couronne renflée en forme de massue, et sur le milieu de la couronne s'élève encore un petit mammelon tronqué, ce qui a valu à ce genre son nom de *Colobodus*."

Since that time teeth of a similar generic character have been described or figured by various authors, *e.g.*, Count Münster (assuming *Asterodon* to be identical), Plieninger, Giebel, Gervais, Meyer, Chop, E. E. Schmid, Alberti, Eck, Winkler, Gürich. W. Dames, and A. S. Woodward. The typical teeth, however—*i.e.* those upon which the 'nipple,' or apical tubercle, is present—must be sought amongst the various species of *Colobodus* and *Lepidotus* (of Plieninger, 1847); whilst intermediate forms, or those from which the 'nipple' has been partly or entirely removed by wearing or by *post-mortem* abrasion, must be sought amongst those described under the various species of *Lepidotus*, *Sphærodus*, *Gyrodus*, '*Tetragonolepis*' (of Winkler, and of Agassiz in part), *Tholodus* and *Thelodus*, *Eupleurodus*, *Sargodon* (not cutting teeth), and even amongst teeth variously attributed to *Saurichthys* and to 'Saurians,' whilst the chisel-shaped, or pre-maxillary, teeth are probably those attributed to *Sargodon tomicus*.

Fragments of the head and trunk and scales of *Colobodus* have been described or figured by H. B. Geinitz, Meyer and Plieninger, Giebel, Meyer, Quenstedt, Eck, Kner, H. Kunisch, W. Dames, J. von Rohon, and A. S. Woodward, and must be sought amongst the various species ascribed to *Gyrolepis* and *Amblypterus*, *Lepidotus*, *Heterolepidotus*, *Eugnathus*, *Pleurolepis*, *Dactylolepis*, and also amongst various Ganoid scales ('Ganoidschuppen' and 'Fischschuppen').

Up to the present neither the teeth nor the scales of *Colobodus* have been recognized as such in Britain by any authors, or, above the Muschelkalk and Lettenkohle, abroad: its occurrence and recognition, therefore, in the Rhætic of Britain is interesting, and the author exhibits typical and transitional teeth which he found and recognized in the Rhætic 'bone-beds' of Wachet and Aust Cliff; worn and abraded teeth ('*Sargodon tomicus*' and '*Sphærodus*') from thence and from Leicestershire; and what are probably the larger cutting teeth from Aust and Leicestershire; also fine characteristic scales and (? head-)bones showing vermiculated sculpture from Aust. All may, for the present, be referred to *Colobodus maximus* (Quenstedt).

Finally, should *Colobodus* prove to be identical with *Lepidotus*, a fusion of *Heterolepidotus* and *Eugnathus* will give *Colobodus* a more extended upward range than has hitherto been supposed.

V.—THE AMMONITE ZONES OF DORSET AND SOMERSET. By S. S. BUCKMAN, F.G.S., Hon. Memb. Yorks Phil. Soc.

THE lower part of the *Murchisonæ*-zone is often intimately connected with the upper part of the *Opalinum*-zone; but, a little higher, there is an horizon characterized by numerous specimens of *Ludwigia Murchisonæ*. The fauna of this horizon corresponds to the *Murchisonæ*-zone of Oppel, and to the Brauner Jura β of Quenstedt. Above the *Murchisonæ*-zone a considerable break in the sequence of strata is frequently met with. In the neighbourhood of Bradford Abbas, however, is found, superior to the *Murchisonæ*-zone, an horizon marked by a very peculiar fauna, in which *Lioceras concavum* and species of the genus *Sonninia* predominate. Taken in a general sense the fauna of this zone (*Concavum*-zone) does not agree with that of Quenstedt's Brauner Jura β or γ, nor with that of the *Sowerbyi*-zone, as illustrated by Waagen, Douville, etc. Further, the *Sonniniæ* of the *Concavum*-zone are, biologically, of an earlier type than those of the *Sowerbyi*-zone.

Continental authors find a marked stratigraphical and palæontological break between the *Murchisonæ*- and *Sowerbyi*-zones; and they wish to draw, at this point, a dividing line between Lias and Oolite, or between Toarcian and Bajocian. It is suggested that the absence of the *Concavum*-zone is the cause of this break; and, in former papers to the Geological Society, the author, in supporting the Continental plan, regarded the *Concavum*-zone as Toarcian.

In the Bradford Abbas district there is a break above the *Concavum*-zone. So far as is known at present, Dundry is the only locality showing a complete sequence; but some years ago a quarry—Coombe, near Sherborne—was open, and it yielded a large series of Ammonites indicating a fauna agreeing with the *Sowerbyi*-zone as illustrated by Continental authors. This quarry has been closed for years; and nothing is known as to how the strata are situated with regard to the *Concavum*-zone below, or with superior horizons. It is richer than Dundry, and is, practically speaking, unique among Inferior-Oolite exposures. It is the only locality in England which yields this particular fauna. So far as is known, the true *Sowerbyi*-zone is absent from all quarries in Dorset and Somerset, with the exception of Coombe and Dundry: and, therefore, the majority of exposures in the district fully support the Continental geologists in their contention as regards a dividing line.

Waagen places a zone of *Am. Sauzei* above the *Sowerbyi*-zone; and an horizon with this species and with a particular fauna is shown in 'the marl with green grains' at Frogden quarry, near Sherborne.

Above this is the zone of *Am. Humphriesianus*, in which the fauna *Stephanoceras* and *Sphæroceras* predominate. This is the equivalent of the *Coronaten-schichten* of Quenstedt's Brauner Jura δ. The upper part of the Brauner Jura δ is the Bifurcaten-schichten; and this corresponds with the *Cadomensis*-beds of Frogden—an horizon which, containing a fauna distinct from the *Humphriesianus*-zone, may therefore be known as the *Cadomensis*-zone.

The strata above this horizon have usually been called the '*Parkinsoni*-zone.' There are several objections to this name; and the strata are capable of more subdivision.

The bed at Halfway House which yields the large *Parkinsoniæ* is superior to the *Cadomensis*-zone. It may be called the *Truellii*-zone. At the top of the limestone of the Broad-Windsor district *Stephan. zigzag* and species of *Morphoceras* are found; and this is a still higher horizon (*Zigzag*-zone). Just below the Fullers' Earth of this same district, in the Fullers' Earth itself of Eype, but in the upper white limestones (about 25 feet thick) of the Bradford-Abbas district, are found *Oppelia fusca* and other species indicating a still higher horizon. It is suggested that the white limestone of the Bradford-Abbas district is contemporaneous with the so-called 'Fullers' Earth clay' of Eype. This horizon may be called the zone of *Oppelia fusca*; and whether this zone belongs to the Inferior Oolite or to the Fullers' Earth depends on whether the observer be regarding the limestones of the Bradford-Abbas district or the clay of Eype cliff.

Several Continental geologists, however, commence the Bathonian with the *Cadomensis*-zone. To this idea the presence of *Parkinsoniæ* and other facts gives considerable support.

VI.—ON THE CONTINUITY OF THE KELLAWAYS BEDS OVER EXTENDED AREAS NEAR BEDFORD, AND ON THE EXTENSION OF THE FULLERS' EARTH WORKS AT WOBURN. By A. C. CAMERON. [Communicated by permission of the Director-General of the Geological Survey.]

IN this paper further evidence is submitted from different parts of the country of the continuity over extended areas of the Kellaways Rock above the Lower Oxford Clay. Several fine excavations, the result of railway enterprise, have afforded sections of these beds in places where their presence was only inferred before. More than the usual thickness is indicated by records recently obtained from deep sinkings and borings in the Midland districts, especially the Bletchley boring of 1886–7.

The extraordinary concretionary stones noticed in Wiltshire by Smith as characterizing this formation, and quarried away years ago at Kellaways for road-stone, jut out in the Valley of the Churn, near Cirencester, and stand about in clusters in the Valley of the Ouse at Bedford like gigantic fungi. The plane of separation of the Upper Oxford and the Kellaways in Bedfordshire is formed by a shelly calcareous band in contact with a shelly cap to the concretionary stones. Where this plane is a broken one there is no development of concreted rock, and the lowest sediment of Upper Oxford clay is loamy, passing down into Kellaways sand. Above the calcareous band there is sometimes an indurated seam of sandy marl, breaking into conical forms; the product, apparently, of stalactitic infiltration. Pits are opened at the outcrop of the Kellaways (a persistent stratum in the Ouse Valley) and are carried down through the Lower Oxford (selenite clay), Cornbrash and Cornbrash clay to Great Oolite limestone, which is quarried for lime-burning; the 'lam earth,' the loamy portion of the Kellaways, being mixed in the mill with the Lower Oxford, which is dug for brickmaking. Excellent sections, showing the above series, are to be seen.

Observations on the extensions of the Fullers' Earth Works at Woburn Sands, with some description of the beds, are given, and the mining industry now springing up is commented on.

VII.—THE MASTODON AND MAMMOTH IN ONTARIO, CANADA. By Prof. J. HOYES PANTON, M.A., F.G.S.

THE writer in this paper gives a complete description of the remains of a Mastodon discovered (1890) in a marl bed near Highgate in the Province of Ontario, Canada, and also the remains of a Mammoth found under similar conditions near Shelburne in the same Province (1889).

Both specimens were discovered by John Jelly, Esq., of Shelburne. The following measurements are given for comparison:—

	Jumbo.	Newburg Mastodon.[1]	Highgate Mastodon.
Longest rib	44 inches	54¾	55½
Humerus	36 ,,	39	40
Radius	– ,,	29	34
Femur	42 ,,	39	47½
Tibia	— ,,	28	29
Tusk	— ,,	104	92 not complete.
Third spinous process	15 ,,	23½	23¾

The bones obtained of the Mammoth are not so numerous, the chief being thirty-one ribs, one 50 inches in length and 11 in circumference; several vertebræ, some 14½ inches across; a massive tusk 12¾ feet with a portion broken off; and a tooth weighing 16¾ lbs. The writer also refers to remains of Proboscoidea found at other points in Ontario, viz. St. Catherine's Dunville, Goat Island, Niagara Falls, and Kimbal, near the western side of the Province.

VIII.—THE CAUSE OF MONOCLINAL FLEXURE. By A. J. JUKES-BROWNE, F.G.S.

FOLDS of the ordinary arch and trough type are generally ascribed to the influence of lateral pressure; but it is not easy to see how a monoclinal flexure which appears in section as a flexure connecting two horizontal bars of strata can have been produced by direct lateral pressure exerted at the ends of the bars.

The author suggests that monoclinal flexuring is a structure impressed upon a horizontal series of uncompressed strata by the displacement of a subjacent mass of faulted and flexured rocks, the lateral compression of the deep-seated mass resulting in the vertical uplift of certain portions of the 'cover.' If a series of stratified rocks rests in a horizontal position on a mass of ancient rock, which has been compressed, indurated, flexured, and faulted before the deposition of the upper series, it is supposed that the lower series of rocks would give way under lateral pressure along the pre-existing faults, and that the blocks which lie between upward diverging faults would be forced to move upwards, carrying with them those tracts of the 'cover' which rest on them. It is evident that these tracts would be divided from those resting on blocks defined by downward diverging faults by faults or monoclinal flexures, the production of a fracture or a flexure depending partly on the thickness and pliability of the strata forming the cover, and partly on the amount of local uplift. It is conceivable that the displacement might take place partly by faulting and partly by flexuring, and that what was a fault near the plane of unconformity might pass upward into a flexure.

The writer desires criticism on the above suggestion, especially from those who will have a chance of seeing the grand monoclinal flexures of the Colorado region during the excursion of the approaching International Geological Congress.

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[1] The Newburg Mastodon is one of the finest ever discovered in America. The bones are in a most excellent state of preservation, and sufficient have been obtained to enable the skeleton to be set up.

IX.—The Origin of Petroleum. By O. C. D. Ross.

IN the course of introductory remarks the author contends that, owing to the mystery surrounding the origin of petroleum, and to the paucity of indications where to seek for it, practical men in this country distrust the permanence of the supply, and hesitate to adopt it for many useful purposes; while the object of this paper is to suggest a way of resolving the mystery which is calculated to dissipate that distrust. The theories suggested by Reichenbach, Berthelot, Mendelejeff, Virlet, Verneuil, Peckham, and others, which are briefly described, make no attempt to account for the exceeding variety in its chemical composition, in its specific gravity, its boiling-points, etc., and are all founded on some hypothetical process which differs from any with which we are acquainted; but modern geologists are agreed that (as a rule) the records of the earth's history should be read in accordance with those laws of Nature which continue in force at the present day. *E.g.*, the decomposition of fish would not now produce paraffin oil; hence we can hardly believe it possible thousands, or millions, of years ago, so long as it can be shown that any of the ordinary processes of Nature are calculated to produce it. The chief characteristics of petroleum strata are enumerated as: I. The existence of adjoining beds of limestone, gypsum, etc.; II. Volcanic action in close proximity; III. The presence of salt water in the wells; IV. The great extent of the production of oil, indicating subterranean receptacles of vast dimensions.

I. The close and invariable proximity of limestone to the wells has been noticed by all writers, but they have been most impressed by its being 'fossiliferous,' or shell limestone, and have drawn the erroneous inference that the animal matter once contained in those shells originated petroleum, but no fish oil ever contained *paraffin.* On the other hand, the fossil shells are carbonate of lime, and, as such, capable of producing petroleum under circumstances such as many limestone beds have been subjected to. All limestone rocks were formed under water, and are mainly composed of calcareous shells, corals, encrinites, and foraminifera, the latter similar to the foraminifera of 'Atlantic ooze' and of English chalk beds. Everywhere, under the microscope, its organic origin is conspicuous. Limestone is the most widely diffused of all rocks, and contains 12 per cent. of carbon. Petroleum consists largely of carbon, and there is a far larger accumulation of carbon in the limestone rocks of the United Kingdom than in all the Coal-measures the world contains. A range of limestone rock 100 miles in length, by 10 miles in width, and 1000 yards in depth, would contain 743,000 million tons of carbon, or sufficient to provide carbon for 875,000 million tons of petroleum. Deposits of bituminous shale have also limestone close at hand; *e.g.* coral-rag underlies the Kimmeridge clay, which is more or less saturated throughout with petroleum, and it also underlies the famous Black-shale of Kentucky, which is extraordinarily rich in oil.

II. The evidence of volcanic action in close proximity to petroleum strata is next dealt with, and extracts in proof thereof are given from several writers. In illustration of volcanic action on carbonate of lime, a sulphur mine in Spain, within a short distance of an extinct volcano (with which the author is well acquainted), is mentioned. That petroleum is not far off is indicated by a perpetual gas flame in a neighbouring chapel and other symptoms; and, these circumstances having attracted his attention, he observed that Dr. Christoph Bishop records in his writings that he had produced sulphur in his own laboratory by passing hot volcanic gases through chalk, which fact further led the author to remark that, in addition to sulphur, *ethylene*, and all its homologues (C_nH_m), which are the oils predominating at Baku, would be produced by treating—

2, 3, 4, 5......equiv. of limestone (carbonate of lime) with
2, 3, 4, 5......equiv. of sulphurous acid (SO^2) and
4, 6, 8, 10......equiv. of sulphuretted hydrogen (H^2S);

and that *marsh gas* and its homologues, which are the oils predominating in Pennsylvania, would be produced by treating—

1, 2, 3, 4, 5......equiv. of carbonate of lime, with
1, 2, 3, 4, 5......equiv. of sulphurous acid, and
3, 5, 7, 9, 11......equiv. of sulphuretted hydrogen.

Thus, we find that

$$\left.\begin{array}{ll}\text{Carbonate of lime} & 2Ca^2CO^3\\ \text{Sulphurous acid} & 2SO^2\\ \text{and sulphuretted hydrogen} & 4H^2S\end{array}\right\}\text{ yield }\left\{\begin{array}{ll}2(Ca^2SO^4.H^2O) & \text{(gypsum)}\\ \quad 4S & \text{(sulphur)}\\ C^2H^4\text{, which is } \textit{ethylene}, & \end{array}\right.$$

and

$$\left.\begin{array}{ll}\text{Carbonate of lime} & Ca^2CO^3\\ \text{Sulphurous acid} & SO^2\\ \text{and sulphuretted hydrogen} & 3H^2S\end{array}\right\}\text{ yield }\left\{\begin{array}{ll}Ca^2SO^4.H^2O & \text{(gypsum)}\\ \quad 3S & \text{(sulphur)}\\ CH^4\text{, which is } \textit{marsh gas}. & \end{array}\right.$$

These and all their homologues would be produced in nature by the action of volcanic gases on limestone.

But much the most abundant of the volcanic gases appear (at any rate at the surface) as steam, and petroleum appears to have been more usually produced without sulphurous acid and with part of the sulphuretted hydrogen H^2S replaced by H^2O (steam), or H^2O^2 (peroxide of hydrogen), which is the product that results from the combination of sulphuretted hydrogen and sulphurous acid ($H^2S+SO^2=H^2O^2+2S$). Thus

$$\left.\begin{array}{l}Ca^2CO^3\\ H^2S\\ 2H^2O\end{array}\right\}\text{ yield }\left\{\begin{array}{l}Ca^2SO^4.H^2O\text{ (gypsum)}\\ \quad\text{and}\\ CH^4\text{, } \textit{marsh gas}\end{array}\right.$$

and

$$\left.\begin{array}{l}2Ca^2CO^3\\ 2H^2S\\ 2H^2O^2\end{array}\right\}\text{ yield }\left\{\begin{array}{l}2Ca^2SO^4.H^2O\text{ (gypsum)}\\ \quad\text{and}\\ C^2H^4\text{, or } \textit{ethylene}.\end{array}\right.$$

Four tables are given at the end of the paper, showing the formulæ for the homologues of ethylene and marsh gas resulting from the increase in regular gradation of the same constituents.

It is explained that these effects must have occurred, not at periods of acute volcanic eruptions, but in conditions which may be and have been observed at the present time wherever there are active solfataras, or fumaroles, at work. Descriptions of the action of solfataras by the late Sir Richard Burton and a British Consul in

Iceland are quoted, also a paragraph from Lyell's "Principles of Geology," in which he says that the mud-volcanoes at Girgenti, in the Tertiary limestone formation, "are known to have been casting out water, mixed with mud and *bitumen*, with the same activity for the last fifteen centuries." Probably at all these solfataras, if the gases traverse limestone, fresh deposits of oil-bearing strata are accumulating; and how much may there not have been produced during fifteen centuries!

Gypsum may also be an indication of oil-bearing strata, for the substitution in limestone of sulphuric for carbonic acid can only be accounted for by the action of these sulphurous gases. The abundance of gypsum in the United Kingdom indicates that large volumes of petroleum are probably stored in places where it has never yet been sought for. Gypsum is found extensively in the petroleum districts of the United States, and it underlies the rock-salt beds of Middlesboro' (N.E. Yorkshire), where, on being pierced, it has given passage to oil-gas, which issues abundantly mixed with brine, and under great pressure from a great depth.

III. and IV.—Besides the space occupied by 'natural gas,' 17,000 million gallons of petroleum have been raised in America since 1860, and that quantity must have occupied 100,000,000 cubic yards; a space equel to a subterranean cavern 100 yards wide by twenty feet high and eighty-two miles in length, and it is suggested that beds of 'porous sandstone' could hardly find room for so much; while vast receptacles may exist, carved by water out of former beds of rock-salt adjoining the limestone.

This would account for the brine; and the increase to the molecular volume of the gases consequent thereon, would in part account for the pressure. It is further suggested that when no such open spaces were available, the hydro-carbon vapours were absorbed into and condensed in contiguous clays and shales, and perhaps also in beds of coal, only partially consolidated at the time. There is an extensive *bituminous limestone* formation in Persia, containing 20 per cent. of bitumen; and the theory elaborated in the paper would account for bitumen and oil having been found in Canada and Tennessee imbedded in limestone, which fact Mr. Peckham (in his article on Petroleum in the 'Encyclopædia Brit.,' 9th edition) thought was a corroboration of his belief that some petroleums are a "product of the decomposition of animal remains."

Above all, this theory accounts for the many varieties in the chemical composition of paraffin oils, in accordance with ordinary operations of Nature during successive geological periods.

X.—THE GEOLOGY OF PETROLEUM AND NATURAL GAS. By W. TOPLEY, F.R.S., Assoc. Inst. C.E.

THE object of this paper is to give a summary of some of the more important facts as to the geological conditions under which petroleum and natural gas are found in various parts of the world, noting the geological ages of the rocks in which they occur, and the influence of geological structure in determining this occurrence.

Few cases are known in which petroleum occurs in rocks older than the Silurian, and none where the amount is of any importance.

Petroleum occurs, but not in large quantity, in a trachyte-breccia at Taranaki, New Zealand. In N.W. Hungary it is found in a trachytic tuff of Miocene age. These, however, are exceptional cases; not only is petroleum not found in volcanic rocks, but in the great majority of cases it is far removed from any known indications of true volcanic action.

The great stores of petroleum and gas in Pennsylvania and New York are in sandstone beds of the Devonian and Lower Carboniferous rocks. Of late years great quantities of gas and oil have been obtained, chiefly in Ohio and Indiana, from the Trenton Limestone (Ordovician).

The oil- and gas-fields of Pennsylvania and New York have a very simple geological structure. The rocks lie comparatively undisturbed, being only gently folded into a series of anticlinals and synclinals parallel with, and along the N.W. side of, the main axes of the Alleghanies. These folds have themselves a gentle inclination towards the S.W. In the Alleghanies, and to the S.E. of the range, where the rocks are greatly disturbed, neither oil nor gas is found. Some of the larger gas wells are on or near the summits of anticlinals, but many are not so placed. In the Trenton Limestone fields of Ohio and Indiana the productive areas are mainly over anticlinals, gas occurring at the crown of the arch, oil on the slopes.

The essential conditions for a largely productive field of gas or oil are—a porous reservoir (generally sandstône or limestone) in which the hydrocarbons can be stored, and an impervious cover of shale retaining them in the reservoir. It is also believed that they only occur where, in or under the porous reservoir, there have been accumulations of fossil remains, the original decomposition of which yielded the hydrocarbons. In the case of the sandstones the original source was probably the fossiliferous shales which underlie them; in the case of the Trenton Limestone the source was probably the fossiliferous limestone itself. The limestone is only productive under certain circumstances; in its normal condition it is a compact rock, and then it contains neither gas nor oil. But over large areas the limestone has been dolomitized, and so transformed into a cavernous and porous rock in which gas and oil are stored. The enormous quantities of gas and oil given out from beds of limestone and sandstone can be fully accounted for when their porous nature, thickness, and extent are taken into consideration. Some of these rocks can contain from $\frac{1}{10}$th to $\frac{1}{8}$th of their bulk of oil.

The high pressure under which gas and oil flow from deep borings can in most cases be fully explained by artesian pressure.

In Kansas gas occurs mainly in the Lower Coal-measures. In Kentucky and Tennessee oil is found in the Ohio shales (Upper Devonian), in Colorado in shales of Cretaceous age. In California it is found in Tertiary strata, mostly much disturbed.

In Canada the chief source, in Ontario, is in Devonian rocks, along a well-marked anticlinal; but gas and oil also occur in the

Trenton Limestone. In the North-West Territories there seem to be great stores of oil in Devonian rocks. Gas and oil now found in Cretaceous strata of the prairies and Athabasca may have been derived from underlying Devonian rocks; but in the Rocky Mountains, at Crow's Nest Pass, oil is probably native to the Cretaceous beds.

In Mexico, the West Indies, and parts of South America, Tertiary strata seem to be the chief source of oil. The age of the petroleum-bearing unfossiliferous sands, etc., of the Argentine Republic (province of Jujuy) is not certainly known; they have been referred by different writers to various ages from Silurian to Tertiary; they are probably sub-Cretaceous. In Europe and Asia the petroleum-bearing beds are of Secondary or Tertiary age, the Palæozoic rocks yielding only an insignificant supply.

In North-west Germany we find petroleum in the Keuper Beds, and more or less in other strata up to and including the Gault. As we pass to the south and south-east from this district we find, as a general rule, that oil occurs in newer strata. The various productive horizons of different districts are as follows:—

North-west Germany	Keuper to Gault.
Rhone Valley Savoy	Jurassic.
Pyrenees Spain	Neocomian and Cretaceous.
Elsass	Oligocene.
Bavaria	Lower Tertiary (Flysch).
Italy	Eocene.
Galicia North-east Hungary	Neocomian to Miocene.
Poland Roumania Caucasus	Miocene.

The important districts of Baku occur on plains over anticlinals of Miocene beds. The petroleum-bearing sands are interstratified with impervious clays, separating the strata into distinct productive horizons.

In Algeria oil occurs in Lower Tertiary beds. The Egyptian petroleum comes from Miocene strata.

Petroleum seems to be unknown in peninsular India; but it occurs in many places along the flanks of the Himalayan range, and also in Lower Burma, generally in Lower Tertiary strata. In Upper Burma and Japan the oil-bearing rocks are probably Newer Tertiary. In all these areas the beds are greatly disturbed, and the same is the case with the great Carpathian field; but it frequently happens that the most productive regions are along anticlinal lines.

In New Zealand oil occurs in Cretaceous and Tertiary strata.

Petroleum and gas almost universally occur associated with brine. This may come wholly or partly from the decomposition of the animal matter which has produced the hydrocarbons, together with the remains of the sea-water originally present in the rocks. But the frequent occurrence of rock-salt in the neighbourhood of petroleum-bearing districts is worthy of note.

Summary.—The main points to be considered in respect of the geological conditions under which petroleum and gas occur seem to be as follows:—

1. They occur in rocks of all geological ages, from Silurian upwards. The most productive areas are Palæozoic in North America, Miocene in the Caucasus.
2. There is no relation to volcanic action.
3. The most productive areas for oil in great quantity are where the strata are comparatively undisturbed. Oil, but in less abundance, frequently occurs when the strata are highly disturbed and contorted, but gas is rarely so found.
4. The main requisites for a productive oil- or gas-field are a porous reservoir (sandstone or limestone) and an impervious cover.
5. Both in comparatively undisturbed and in highly disturbed areas, an anticlinal structure often favours the accumulation of oil and gas in the domes of the arches.
6. Brine is an almost universal accompaniment of oil and gas.

XI.—VULCANICITY IN LOWER DEVONIAN ROCKS. THE PRAWLE PROBLEM. By W. A. E. USSHER, F.G.S. [Communicated by permission of the Director-General of the Geological Survey.]

IN the area extending south from the Middle Devonian volcanic series of Ashprington to the Prawle there appears to be no proof of the occurrence of strata older than Lower Devonian. There is no adequate reason for assuming that Lower Devonian rocks as old as the Gedinnian occur on the surface, and there is no certainty that the lowest beds are older than the Lower Coblenzian.

The occurrence of local volcanic action in Lower Devonian time is proved by a series of diabases and tuffs near Dartmouth, in the Kingswear Promontory, near Stoke Fleming, and in the line of country west from Torcross.

In association with the northern chloritic band (running from the mouth of the valley on the north of Hull Sands on the east to Hope on the west) we find volcanic materials identical in character with varieties of volcanic rocks associated with the Devonian slates in the line of country west from Torcross; and here and there in the line of country west from Torcross the volcanic rocks assume a more or less pronounced chloritic aspect. The junction of the slates on the north with the northern chloritic band is a strictly normal one, the chloritic rocks being almost invariably separated from the slates by brown volcanic materials which are everywhere succeeded by the same type of Devonian slate, and in the Southpool Creek and many other sections are found to pass insensibly into the chloritic type. In the Southpool Creek section a hard bluish diabase (? aphanite) occurs in the chloritic band. In the southern chloritic districts of the Prawle the volcanic rocks may still be here and there detected by texture or colour. Volcanic rocks occur in the mica schists of the Start coast, and can be detected even when only a few inches in thickness. At Spirit-of-the-Ocean Cove chloritic rock with much calcspar occurs in association with tuffs and a grey rock with incipient foliation, presenting a slightly gneissoid appearance, and apparently a much sheared diabase. The association of the chloritic rocks with the mica schists is of as intimate a nature as that of the volcanic materials with the unaltered slates to the north. From these facts it seems evident that the chloritic series is nothing more than a Devonian volcanic group, of which the Torcross, Stoke Fleming, Dartmouth, and Kingswear coast tuffs and diabases were either sporadic offshoots or evidences of more or less contemporaneous local vulcanicity.

The more evident crinkling of the mica schists in contact with the chloritic group seems to be due to their comparative softness and greater fissility during the crumpling and contraction to which both were subjected.

The comparative suddenness of the transition from unaltered to more or less highly altered rocks may be explained by the lessening of strain (in receding from the harder masses of ancient rocks, against which the beds were jammed), being coincident with the thinning out of the volcanic materials northward, and furthermore favoured by the soft character of the grey slates with limonitic interfilmings which everywhere bound the northern chloritic band on the north. It is not the author's present purpose to enter more particularly into the stratigraphy of this interesting region, which is not yet thoroughly worked out. It only remains to acknowledge the prior claim of Mr. Somervail to the suggestion of the identity of the Devonian diabases with the chloritic rocks.[1]

XII.—NOTE ON BOULDERS AT DARLEY, NEAR MATLOCK, DERBYSHIRE.

By HERBERT BOLTON.

DURING the excavation for a small lake close to the Midland Railway Station at Darley, near Matlock, a cluster of fifteen boulders were exposed, the size of several being sufficient to justify an examination. The boulders lay in a bed of Boulder-clay which had a thickness of nine feet.

The upper part of the clay was of a strong yellow colour and very stiff. Below, the colour varied from yellow to brown and red, and pockets of sand were common.

Only two boulders were rounded, the rest being sub-angular, on their upper half, and fairly angular on the lower.

All the boulders consist of gritstone identical in character with the Chatsworth grit of the adjoining hills.

No striations occur in the boulders, but this may be due to the original surface having crumbled away.

A series of parallel and shallow grooves occur on the side of the largest boulders, and a deep hollow has been scooped out of its southern face.

The major axis of the undisturbed boulder was approximately north and south, the general direction of the cluster being 8° west of north. The blocks were arranged in the order of their weight in a north to south direction. The clay was found to rest upon a deposit of the nature of river gravel.

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[1] The views above expressed are those to which the author himself has been led, but they have not yet been fully considered and adopted by the Geological Survey.

The writer is of opinion that the clay is redistributed Boulder-clay from the adjoining heights, and that the boulders were brought down at the same time from the line of outcrop of the grit.

He is led to this conclusion by the local character of the boulders, the almost total absence of foreigners, and the character of the clay.

The red and brown colour of the latter at its base seems to show that oxidation of the contained iron has proceeded for a longer time than in the case of the uppermost clay. This would be expected if the clay was redistributed, for the basement mass of clay must have been the superficial clay of the heights. The enclosed sand would also indicate the complete disintegration of boulders of grit-stone, etc., whilst the clay was in its primary position.

The amount of disintegration which has taken place since redistribution is marked by the crumbling surface of the large boulders.

The general direction of the boulders may be explained by noticing that the river flows from north to south.

REVIEWS.

I.—Pineal Fontanelle of Placoderm and Catfish. By Bashford Dean, A.M., Ph.D. Nineteenth Report of the Commissioners of Fisheries of the State of New York, pp. 307–363, pls. i.–xiv. (Albany, 1891.)

DR. DEAN, as assistant to Prof. Newberry, of Columbia College, New York, has had the privilege of studying the fine skulls of *Dinichthys* described by the Professor. He has directed attention more especially to the pineal region of the cranial shield, and now attempts to show, from a study of the pineal foramen in the Siluroids, that the well-known foramen in *Dinichthys* and its allies must have been the seat of a median eye. The aperture is remarkably minute, and after a detailed description of the surrounding bone, Dr. Dean remarks that this foramen "becomes naturally the pinhole of the camera to produce an inverted image upon the retina, a condition almost unparalleled for primitive simplicity, obviating as it does a diaphragm (iris), as well as the specialized humours, aqueous, crystalline, and vitreous. Moreover, it will at once be seen to do away as well with all devices for accommodation, since the focal distance would be practically the same for a point at any given distance." The author's numerous dissections of the soft parts of the Siluroid head afford material for a valuable series of notes and figures; and it seems to be demonstrated that the pineal eye exists in a very degenerate condition. At the same time, we fail to recognize in the new memoir any additional evidence in favour of the supposed genetic connexion between the Coccostean fishes and modern Siluroids. Dr. Dean's researches merely result in the plausible explanation of a feature in the cranial roof of *Dinichthys*, by reference to a nearly analogous structure in an existing type of fish. A. S. W.

II.—CRETACEOUS FISHES FROM MEXICO.

IN a recent description of a series of Jurassic and Cretaceous fossils from Mexico (Palæontographica, vol. xxxvii. pp. 189–194, pl. xxviii. figs. 14–18, pl. xxix. fig. 3, pl. xxx. figs. 3–5, 8–10), Dr. J. Felix refers to some fish-remains from the Neocomian of Cerro de la Virgen, near Tlaxiaco. The new genus and species, *Otomitla speciosa*, is founded upon a skull and badly preserved trunk, apparently of a Lepidosteoid ganoid. The bones of the head and opercular apparatus are externally sculptured, and the dentition consists of very large conical teeth; the vertebræ are completely ossified, biconcave; and the scales are rhomboidal, much broader than deep on the ventral aspect. The imperfectly known *Neorhombolepis*, of the English Chalk, presents several striking features of resemblance. Associated with *Otomitla* it is interesting to find recognizable remains of a species of *Belonostomus*, described under the name of *B. ornatus*. The vertebræ in this fish are completely ossified, as in some other Cretaceous species.

Though limited to the description of two definable genera and species, Dr. Felix' contribution is of great interest as relating to a region that has not hitherto yielded fossil fishes. *Belonostomus* has now been found in the Cretaceous of Europe, India, Mexico, Brazil, and Queensland; and the geographical distribution of the genera of fishes of the Cretaceous period is gradually becoming a subject concerning which so many facts are known as almost to justify an attempt at broad generalizations. A. S. W.

III.—WINCHESTER COLLEGE NATURAL HISTORY SOCIETY. "GEOLOGICAL NOTES." Fcap. 8vo. pp. 32. (Winchester, J. Wells, 1891.) Price 1*s*.

FOR many years the above Society has published in its Reports lists of the Fauna and Flora, both Recent and Fossil, of the neighbourhood of Winchester. The lists of Recent forms attained some years ago to such a degree of completeness, that their repeated issue seemed unnecessary. The list of Fossils, on the other hand, has been rendered, through new discoveries and new views, somewhat antiquated, and it is a happy thought of Mr. C. Griffith to issue it in a separate and more convenient form.

The present edition begins with a short description of the Chalk of Hampshire, its zones and its foldings. Then follows a list of Pits and Sections near Winchester; for each of these is given the zone and a complete list of fossils, while to most are added the dip and any other information of interest: twenty-five such localities in the Chalk, and six in the Eocene are thus recorded. The Chalk in the Winchester Anticlinal extends from the Senonian zone of *Belemnitella quadrata* down to the zone of *Holaster subglobosus* in the Cenomanian. From it 186 species, excluding Plants and Foraminifera, are here recorded. These are displayed in a Table, arranged according to the main zoological divisions, which shows the vertical distribution of each species through the zones. Thus, while the first list should be of much value to the local collector, the second affords matter for thought to the stratigraphical geologist. Care appears to have been taken in determining the species, and the names are commendably up to date; it would appear that many new forms need description.

The public spirit shown in the printing of these lists deserves support at the hands of all interested in Cretaceous Geology. Since it must be some years before a fresh edition can be brought out, Mr. Griffith proposes to issue a supplementary sheet from time to time.

F. A. B.

IV.—L'Evolution des Formes Animales avant l'Apparition de l'Homme. Par F. Priem. 8vo. pp. 384 and 175 Figures. Bibliothèque scientifique contemporaine. (J. B. Baillière et Fils, Paris, 1891.) 3 fr.

Did there exist a class of people perfectly familiar with the most technical terms of modern science, and deeply interested in its most abstruse problems, yet at the same time absolutely ignorant of all its conclusions, then we could understand the commercial value of books like the present. As for its educational worth, a book that compresses the history of "all the animal forms discovered in geological strata" into 363 small pages of large leaded type, and that enters therewith into such details as the description of the spines of a single species of *Cidaris*, may amuse the palæontologist, but can hardly instruct the student.

We do not wish to be hard on Professor Priem; he has done his hack-work no worse than this sort of thing is usually done. While abstaining from rash speculation on his own account, he has given, as a rule, the views of the most recent writers, among whom he has naturally gleaned much from Neumayr, and to a commendable absence of dogmatic statement he joins much fairness in stating the views of those with whom he does not agree. For example, while the history of the Cephalopoda is far sounder than that given in most text-books, the views of Munier-Chalmas on *Spirula*, and Steinmann on *Argonauta*, though not accepted, are given considerable (some would say too much) prominence.

It is the easiest thing in the world to pick holes in patch-work, but the occupation is somewhat unprofitable. Here, however, are a few weak places for the author's consideration. *Globigerina* ooze is not found at a greater depth than 4000 mètres, because, suggests M. Priem, the high pressure of the water breaks these fragile shells. The tentacles of Echinoderms are *not* called "ambulacra." The Echinoderm skin is hardly "incrustrée [*sic*] de calcaire." The "dorsocentral" of a crinoid is *not* the same as either the "centrodorsal" or the mythical "orocentral." The larva of *Antedon* resembles many genera rather than *Pentacrinus*. If the Neritidæ are descended from the Trochidæ, how does M. Priem explain the total difference in their radulæ? *Helix* owns a more remote antiquity than the Lower Eocene; it has been found in the Gault.

And what on earth induced the author to pen this sentence: "Le nombre des chambres chez les *Orthoceras* est invariable"?

The publishers have secured numerous illustrations, the better ones being reprinted from Professor Gaudry's "Enchaînements du Monde Animal," recently reviewed in these pages. But we regret to see once more the caricature of *Ichthyocrinus piriformis*, that, under the name of "*Cyathocrinus pyriformis*," disgraces p. 89. No *Trigonia* ever had lines of growth like those drawn in fig. 82; the engraver cannot have seen the shell. Fig. 106, a worse copy of a bad original (Pictet 'Traité de Paléont.' pl. liii. fig. 6) hardly represents the typical form of *Amaltheus margaritatus*. The drawings of *Coccosteus*, *Pterodactylus*, and *Megatherium* are more than old, they are senile; it is to be hoped that their errors will soon pass to the land where all things are forgotten.

The printer seems to have placed the blocks at his own sweet will; some Gasteropod and Cephalopod shells are placed with the mouth upwards, others with it downwards, while even a skull of *Teleosaurus* (fig. 149) is topsy-turvy. And here is a little sum for him: if every volume of the 'Bibliothèque scientifique contemporaine' has as many misprints as the present one, how many thousands do they amount to? F. A. B.

V.—TRANSACTIONS OF THE LEEDS GEOLOGICAL ASSOCIATION. Part VI. 1890–91. Edited by W. LOWER CARTER, M.A., F.G.S. (Leeds, 1891.)

AS indicated by the new part of its Transactions just received, the Leeds Geological Association still continues to maintain its position as one of the most flourishing of provincial societies. While specially concerned with the facts of Yorkshire Geology, and devoting much time to field-excursions, the Association also encourages the discussion of wider subjects of general interest; and useful abstracts of all the communications are comprised in the first half of the Report. The Presidential Address (by Mr. C. Brownridge, F.G.S.) relates to the building and paving stones employed in Leeds. Other contributions to local geology are entitled "A Geological Tour through Durham into Cumberland" (by Mr. W. Cheetham), "A Long-buried Oak" (by Mr. B. Holgate, F.G.S.), "A Geological Episode as recorded in the Ingleton Granite" (by Mr. T. Tate, F.G.S.), and "From Kettleness to Saltburn" (by Mr. E. Hawkesworth). Among more general papers, Prof. A. Lupton discusses "A Gold Mine, a Slate Mine, and a Salt Mine," while Mr. J. E. Marr has some brief remarks on "The Backbone of England." Other readable summaries of special geological subjects are also given; and the latter half of the Report is devoted to a well-written account of the Field Excursions, which will prove of much value to all geologists who wish to study the district. The Membership of the Association is well maintained, and the latest additions to the list of Honorary Members are the names of Messrs. J. E. Marr and A. Smith Woodward.

VI.—THE ANCESTRAL HORSE.

NOTICE SUR *l'HIPPARION CRASSUM* DE ROUSILLON. By MARIE PAVLOW. Bull. Soc. Imp. Nat. Moscou, 1891.

QU'EST CE QUE C'EST QUE *l'HIPPARION*. By MARIE PAVLOW. *Ibid.*

IN these brief notes Madame Pavlow re-states her views as to the specialized character of *Hipparion*, and the impossibility of its being an ancestral form of *Equus*. She regards the lower dentition ascribed to *H. crassum* by Depéret as erroneously determined, preferring to assign it to *Equus*; and the supposed limbs of the Indian *H. antilopinum* seem to her to be more probably referable to *Equus stenonis*.

REPORTS AND PROCEEDINGS.

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I.—ADDRESS TO THE GEOLOGICAL SECTION OF THE BRITISH ASSOCIATION, BY PROFESSOR T. RUPERT JONES, F.R.S., F.G.S., President of the Section, Cardiff, August 21st, 1891.

1. *Introduction.*—The *black stones that burn* probably came to be known by pre-historic people through accident, here and there, long before any notion of their worth to the community at large was entertained. Wood at first, and then charcoal, supplied fuel far into historic times, on every hand, except perhaps in China. In the first century of the Christian era the Romans, occupying England, met with coal, and probably learnt its use from the natives. It seems, however, to have been disregarded during the Saxon conquest and domination of this Island; but by the beginning of the twelfth century the use of coal was well in hand again, as shown by old charters relating to places in Scotland and the county of Durham.

The history of the use of coal is treated of in the following books:—'The Coal-fields of Great Britain: their History, Structure, and Resources, with notices of the Coal-fields of other parts of the World.' By Edward Hull, M.A., etc., with maps and illustrations. 8vo. London. First edition, 1861; second, 1861; third, 1873; fourth, 1881. 'Coal: its History and Uses.' By Professors Green, Miall, Thorpe, Rücker, and Marshall. Edited by Professor Thorpe. 8vo. London, 1878. Also in the unpretentious pamphlet, 'The History of Coal.' By the Rev. Thomas Wiltshire, M.A., etc. 8vo. London, 1878. Of course the most comprehensive work on the British Coal-measures is the 'Report of the Commissioners appointed to Inquire into the several matters relating to Coal in the United Kingdom,' 3 vols., with maps and sections. Fol. London, 1871. Other valuable works are: W. W. Smyth's 'Coal and Coal Mining,' 8vo. 1867, and later editions; and Richard Meade's 'Coal and Iron Industries of the United Kingdom,' etc. 8vo. London, 1882. 'Coal: its Geological and Geographical Position.' By Professor John Morris, 8vo. London, 1862, although only a pamphlet, is valuable for its information.

The subject of Coal and the Coal-measures is abundantly treated of in the scientific literature of this century in nearly all parts of the world, and it would be useless to endeavour to do justice to its bibliography. Besides having had the advantage of the labours of the many eminent foreign geologists who have advanced our knowledge of the subject in one or other of its various aspects, both by original research[1] and by condensing published results in treatises and manuals for students,[1] we have had some of the most enthusiastic students of the natural history of the Carboniferous strata and fossils in our own country and within our own times. Their names must frequently occur in speaking of coal and its belongings.

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[1] Especially Sternberg, Brongniart, Goeppert, Petzholdt, Geinitz, Unger, Schimper, Weiss, Renault, and Grand'Eury.

The text-books and manuals of geology by De la Beche, Phillips, Trimmer, Lyell, Ansted, Jukes, Geikie, Prestwich, Green, Etheridge, and others, are safe guides: the Memoirs of the Geological Surveys of England and Wales, Scotland, Ireland, and India are mines of scientific wealth as regards the same matter; our palæobotanists Lindley, Hutton, Artis, Witham, Morris, Hooker, Binney, Bunbury, Dawes, Williamson, Carruthers, Balfour, Kidston, etc., have given us good results; and others, not specialists, have written good matter for our consideration. Abroad, among our American friends, we have, or have had, several of the State geologists (Emmons, Lesquereux, Rogers, Lesley, Newberry, Dana), who have studied the Coal-measures with care, besides Steinhauer, Brown, and others; but no one has so earnestly and successfully given his serious attention to this branch of geology and palæontology as Sir J. W. Dawson, of Montreal, not long since President of the British Association when we met at Birmingham in 1886. His numerous memoirs and elaborate work on 'Acadian Geology' supply abundant facts and sound theories in elucidation of the history of the Coal Period. Sir W. E. Logan, who indeed by his studies in South Wales was the first to give geologists a clue to the interpretation of much that was very obscure about coal, worked with Sir J. W. Dawson in the Nova-Scotian coal-field; and so also did Sir Charles Lyell, who there and elsewhere devoted much energy and acumen to the elucidation of the origin and formation of coal.

The indexes of successive volumes of the 'Geological Record' show how abundant have been papers and books on Coal, Coal-mines, Coal-fields, Carboniferous fossils, and correlative studies, within the last few years, abroad and at home. The subject is so extensive that we must confine ourselves to the coal of South Wales.

2. *The Coal-field of South Wales, as studied by Logan, De la Beche, and others.*—Had it been that the stone axe found in Monmouthshire by Edward Lloyd[2] were really associated with the outcrop of the coal there, and if truly belonging to the Stone age and used in hewing coal, as Professor Hull's mention of it seems to imply,[3] it would, indeed, have been one among the few known evidences of prehistoric coal-mining, and would tend to show that South Wales was among the places first made to yield this useful mineral.

At the present day South Wales and Monmouthshire yield coal in greater quantity and of more value (by over a million pounds sterling a year) than the coal-fields of Northumberland and Durham, or of Yorkshire and Derbyshire; and considerably more (by nearly £5,000,000) than that of the Clyde Basin and associated coal-fields of Scotland. Indeed, the annual value of the coal produced in South Wales with Monmouthshire may be said to be about eleven millions out of the whole forty-five millions sterling estimated as the value of the coal at the pit's mouth throughout the United Kingdom.

The great coal-field of South Wales has the especial credit of having supplied some of the earliest and most important facts and phenomena illustrative of the geological succession of the materials of the Coal-measures, and of the natural history of the coal itself. To the perserverіng energy and accurate observation of Sir William E. Logan and Sir Henry T. De la Beche South Wales gave up the secrets of coal-growth, strengthening some earlier suppositions, correcting others, and establishing a firm basis for the theory that the coal has, for by far the most part, been formed of plants growing where the coal now lies, although some local varieties have arisen from the occasional driftage of floating timber and herbage, and of long-continued maceration of vegetable matter in lakes and pools elsewhere.

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[1] Omalius d'Halloy, Leonhard and Hoernes, Vogt, C. D'Orbigny and Gente, Beudant, Credner, Lapparent, Contjean. and others.

[2] 'In a steep rock called Craig y park, and others in the Parish of Istrayd Dyvodog, we observed divers veins of coal, exposed to sight as naked as the rock; and found a flint axe, somewhat like those used by the Americans' (*Phil. Trans.* vol. xxviii. 1714, p. 501; in a letter dated September 22, 1697).

[3] The Coal-fields, etc., 4th edit. p. 12.

Mr. (afterwards Sir) W. E. Logan, having for several years worked on the geology of South Wales, in 1837 gave his maps and information to the enthusiastic promoter of the Geological Survey of the British Islands, Mr. (afterwards Sir) H. T. De la Beche, for public use in the construction of the Survey Map and in developing the structure of the country. The first volume of the "Memoirs of the Geological Survey," 1846, contains at p. 145, Sir H. T. De la Beche's acknowledgment of Sir (then Mr.) W. E. Logan's gift of the valuable results of his investigations in the Coal-measures and discovery of the nature and meaning of the frequent underclays, an account of which Mr. Logan had already published in the "Annual Report of the Royal Institution of South Wales" for 1839; in the "Proceedings of the Geological Society of London," vol. iii. February, 1840, p. 276, and March, 1842, p. 707, etc., and "Transactions of the Geological Society," second series, vol. vi. 1842, p. 491, etc.

The hypotheses of the formation of coal offered by earlier writers are carefully reviewed in De la Beche's elaborate memoir; and the growth of opinion as to coal having been made by plants growing in place is traced from De Luc (1793), Lindley and Hutton (1833 and 1835), Adolphe Brongniart (1838), to W. E. Logan, by whom, indeed, it was fully established before 1837. Opinions as to the nature of the *Stigmaria ficoides*, so abundant in the 'underclays,' are also referred to; and that it is really the root of *Sigillaria* is accepted on the good authority of Brongniart and Binney (p. 150). Dr. Buckland's summary (in his Anniversary Addresses to the Geological Society 1840 and 1841)[1] of what had been advanced by British geologists in the elucidation of the Coal-measures and their natural history comprised mainly the observations made by Ansted, Hawkshaw, Barber, Beaumont, J. E. Bowman, and particularly W. E. Logan. He stated in his Address of 1840 that "some of the vegetables which formed our beds of coal grew on the identical banks of sand and silt and mud which, being now indurated to stone and shale, form the strata that accompany the coal; whilst other portions of these plants have been drifted to various distances from the swamps, savannahs, and forests that gave them birth, particularly those that are dispersed through the sandstones, or mixed with fishes in the shale beds."

Dr. Buckland's summary in 1841 is given by De la Beche[2] "as expressing his opinion that the *Stigmaria ficoides* [which was at that time still regarded by many as an individual floating plant], growing in ponds or lagoons in the localities where we now discover its remains, by mixture with mud or silts disseminated among them, formed the underbeds, upon which also grew the plants which now form the coal-beds, these latter, by subsidence being covered by sand or mud, forming sandstone or shale, between the coal strata, successive coal-beds being formed as the necessary conditions arose." Sir (then Mr.) C. Lyell's important additions to the subject, then lately given in his "Travels in North America," two vols., 1845, quoted and applied by De la Beche, were subsequently enlarged in his "Second Visit," etc., two vols., 1849, and in his "Elements of Geology," edition 1851, and subsequently.

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[1] Proceed. Geol. Soc. vol. iii. pp. 229 and 487.

[2] Mem. Geol. Survey, vol. i. 1846, p. 152.

De la Beche's Memoir, after having presented some explanation of geological phenomena, and treated of the general range and occurrence of the Silurian and Devonian rocks in the southern moiety of Wales and the South-western Counties of England, proceeds to describe the Carboniferous strata, and at p. 143 takes up the Coal-measures; and his work remains a classic authority on the subject. De la Beche's account of these strata has not been much modified, except by the descriptions of many additional fossils, and details about the special characters of those then known.

Other information, however, on the past and present conditions of the South-West Coal-field is found in Mr. (now Sir) A. C. Ramsay's paper "On the Denudation of South Wales and the adjacent English Counties," in the same volume of the "Memoirs of the Geological Survey"; and very much has been added by local observers, as shown by numerous papers on this coal-field and its constituents in the Reports, Proceedings, and Transactions of the Scientific Societies of South Wales.

3. *Origin of Coal.*—Coal is now generally accepted as being a compressed and chemically altered mass of ancient vegetables. The tissue of some of the trees and other plants may be detected in the substance more or less distinctly by fracture, by burning, and in thin sections. In some cases trees occur rooted in the attitude of growth, their stems rising upwards and their roots remaining in or below the coal. The accumulation of coal as seams of varying thicknesses, in very numerous parallel beds, can be explained by the gradual and long-continued subsidences of long and wide tracts of old marginal sea-beds, estuaries, and lagoons, with adjoining lands,[1] all more or less invested with vegetation. At the same time limited, isolated, and lenticular patches and nests of pure coal, usually in sandstone, have been probably due to floating masses of vegetation, matted plants and trees, becoming waterlogged and sinking in estuaries and shallow seas.

Some highly bituminous coal, like cannel and torbanite, may have been due to limited accumulations of macerated plants rotting in water; or to the bursting of those natural reservoirs, like peat-bogs, and a local arrangement of the resulting flow of Carbonaceous mud.

Mr. W. Galloway, in his memoir "On the Mode of Occurrence of Coal,"[2] carefully places before his readers the two sets of opinions about the origin and formation of coal. First, as to the place of growth and of carbonization being on the same ground, following De la Beche's statements and conclusions; and, secondly, as to the accumulation of vegetable matter, some dead and broken, some already decomposed, derived from the forests and herbage of marshy lands, and deposited in great lakes (as expressed by C. Grand'Eury in the "Annales des Mines," 1882), with the *Stigmariæ* living and dying as water-plants (as they were at first regarded, and thought to have been formed of a central body and long-spreading arms and leaves); while tall trees grew here and there on the water-side, until, falling down, they lay prostrate in the black mud; or, breaking off, left their rotting stumps still standing upright.

Mr. Galloway accepts the latter opinion to some extent, because he finds the roots in underclays to have no direct communication with the coals above them,—on account of the presence of persistent shaly layers, or, 'partings,' traversing coal-beds, and very intimately passing into the coaly matter itself,—on account of a seam being cannel-coal, blackband-ironstone, and shale in different parts of its extent, with a coal lying on it without an intervening underclay; and if this shows that a coal can have been formed without an underclay, he argues that any underclay need not have been necessarily the soil of a coal-seam. He acknowledges the subject to be one of difficulty; and it seems to me that some at least, if not all, of the difficulties have been already removed by De la Beche, Lesley, Lyell, Dawson, and other observers.

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[1] The Coalfields of Great Britain, 4th edit. p. 81, etc.

[2] Report and Transactions of the Cardiff Naturalists' Society, vol. xvii. (for 1885), 1886, pp. 20–34.

4. *Area of the Coal-growth.*—For knowledge of what ruled the local occurrence of coal, we owe a great debt to Mr. R. A. C. Godwin-Austen, who had studied the geology of the South-western Counties with De la Beche. To him we are indebted for the approximate demarcation of the bounds and margins of the Carboniferous Formations, particularly for the probable land-limits and outward extension of the Coal-measures. In his valuable memoir "On the possible Extension of the Coal-measures,"[1] he explained the reasons for his indicating on the map then communicated to the Geological Society the physical configuration of North-western Europe at the close of the Palæozoic period, and the outline of the surfaces which supported the coal-vegetation. He concluded to define the place and range of this old coal-growth of what is now Western Europe as—

"An internal sea, around and occasionally over large parts of which the peculiar vegetation of the time was developed and entombed as the area rose and sank. A region with a central depressed area, such as Australia is supposed to present, and going down, by means of a long series of oscillations, would ultimately present just such an assemblage of deposits as our own Carboniferous group" (p. 73).

A further reference to this kind of level or hollow region is as follows:—

"The large level tracts which lie west of the Blue Mountains in Australia into which the Lachlan, the Darling, and the Murrumbidgee, discharge." (Godwin-Austen's Lecture, Royal Institution of Great Britain, April 16, 1858.)

Such an area had also been indicated in Sir H. De la Beche's note to p. 296 of his memoir above mentioned, where he refers to 'the great area extending from the country drained by the Volga, eastward through eighty degrees of longitude into China, and from which the waters find no course outwards to the main ocean or to the seas connected with it.' With a gradual depression—with the detritus swept in by the rivers—and with a suitable flora and climate, there might here be both accumulations of vegetable matter grown in place, as well as limited deposits of drifted plants, under different conditions. De la Beche moreover, referred (p. 146) to the long flat coast of the eastern seaboard of South America, with its great rivers and abundant flora, as being analogous to some parts, at least, of the areas on which the coal-seams were formed.

The area of coal-growth in this North-west European region is represented on Mr. R. A. C. Godwin-Austen's map[2] as a littoral belt (varying in width as now exposed at the surface), reaching, in an approximately semicircular or bay-like shape, from the Elbe near Magdeburg, and north of the Hartz, westward to the valley of the Ruhr, including a southern extension to Marburg; and, taken up again, it passes from Ruhr to Aix-la-Chapelle, and to Namur and Charleroi; then by the Franco-Belgian coal-field to Calais, and beneath the valley of the Thames to Bristol, Forest of Dean, and South Wales, south of the Old Red area, towards Ireland. On the eastern side of Hereford, and along the east border of the old rocks of Wales, the range of the coal-growth is shown by the coals appearing here and there along the Severn and the Dee; and doubtless it widened out considerably eastward across what is now England. Continuing northward it occupied Northumbria, and stretched westward locally between the old Cumbrian land and the South Highlands; passing around the east end of the latter, it was strong across what is now Central

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[1] Quart. Journ. Geol. Soc., vol. xii. 1856, pp. 38–73; also Report Coal Commission, 1871, pp. 424 and 511, with plates; and Rep. Brit. Assoc. for 1879, p. 227, pl. xiv.

[2] Pl. i. Q.J.G.S., vol. xii. 1856.

Scotland, with indications in North Ireland. Thus the coal-growth invested the southern and western edges of Godwin-Austen's 'internal sea' above-mentioned, and extended westward by two outlets: one at its south-west corner, by South Wales; and the other on the north-west, by Central Scotland, each into the Irish area, and thus roughly surrounding the several older Palæozoic lands of Wales, Ireland, Cumbria, and South Scotland.

In Professor Ramsay's account of the denuded remnants of the Welsh coal-fields[1] the stretch of coal-growth along the border of the old Cambrian land is clearly indicated in his statement, that—

"One denuded edge of these accumulations now forms part of the counties of Pembroke, Caermarthen, Glamorgan, and Monmouth, and is elsewhere exhibited in the Forest of Dean, the narrow strips of Coal-measures north of May Hill in Gloucestershire, the Clee Hills (outliers of the Forest of Wyre and Coalbrookdale), the coal-fields south and west of Shrewsbury, and that of Oswestry, Wrexham, and Mold. All these are but fragments of one great original coal-field, once mantling round North Wales and the older rocks west of the Severn and north of Bristol Channel."

Both north and south, however, of the old Cumbrian area are a few seemingly isolated patches of coal; but the Whitehaven field is really the western portion of the North-of-England coal-growth; the coal of Anglesea belongs to the westward extension of the Lancashire field; and that of Ingleton is a remnant of the northern part of the latter towards the margin of the old Cumbrian land.

5. *Coal-field of South Wales: its extent, thickness, and constituent strata.*—The valuable coal-field of South Wales (estimated by some to occupy 640,000 acres, and stated by others to be 906 square miles in extent) forms an irregular oval basin or trough lying E. and W. (about fifty-six miles long, from Pontypool to Caermarthen Bay), with a narrow extension westward beyond Caermarthen Bay, through Pembrokeshire to St. Bride's Bay (about seventeen miles long). The greatest width is about sixteen miles. In 1881 there were 662 collieries at work (see Hull, 1881). The strata of the whole area have been much undulated and broken; on the south they dip at an angle of 45°, and at about 12° on the north. Great faults, approximately north and south, alter the levels from forty to a hundred fathoms; they are generally filled with clay; but one, near Swansea, many fathoms wide, is filled with fragments of the broken strata (Trimmer).

A strong *anticline* once passed along the middle of the trough (E. and W.), with its complemental *synclines*, one on each side. These have been somewhat shifted (the eastern moiety towards the S.W., and the other to the N.E.) by a great oblique *fault* coincident with the valley of the Neath. Except at Swansea and Caermarthen Bays, the outcrops of the lowest part of the series of strata, of irregular width, are continuous around the coal-field. About seven unequal patches of the upper measures have been preserved from denudation in the *synclines*. Two of these areas are in the eastern moiety; both long, but the southern syncline retains only a narrow and interrupted series of patches.[2] The Ebbw, the Sirhowy, the Rhymney, and the upper part of the Afon cross the former; the Taff and the Rhondda, with their branches, cross both synclines; and the Ely and Ogwa cross the lower syncline. The respective valleys give local opportunities for opening certain beds, and afford facilities for roads and railways from the hills to the sea-coast. In the western moiety there are five circumscribed areas of the upper measures in the two synclines; the united Amman and Llwchwr River runs between four of them, and the Tawe between two and across one (just north of Swansea). The favourable position for mining some of the measures is due to the local angle of dip in the synclinal strata; and, indeed, without the anticlinal arrangement some of the coals could never have been reached even by deep mines.[1]

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[1] Mem. Geol. Surv. vol. i. 1846, p. 314.

[2] See Hull's 'The Coalfields,' etc., 4th edition, pp. 88, etc., and map.

Mr. Etheridge (in his new edition of Phillips's "Manual of Geology," 1885, p. 238) mentions that in the southern part of the western moiety the Coal-measures have a thickness of 11,000 feet; and that on the northern side of the anticlinal axis there they are 7000 feet thick, and that near Britton Ferry, in the middle, they diminish to 4800 feet on that side.

Taking the whole basin or trough, it may be roundly said that in the north-east side the coals are mainly *coking* or *partly bituminous;* to the west and north-west they are *anthracitic;* and in the south *bituminous* or *gaseous;* and more especially that "in the Aberdare area the coals are very free-burning, but at the same time smokeless; hence their importance for steam purposes, especially the Aberdare four-foot steam-coal."[2]

The physical features and structural condition of the South-Welsh coal-field, also the occurrence of fossils, were succinctly treated of by G. P. Bevan in the "Geologist," vol. iii. 1860, pp. 90–99.

The order and thickness of the strata belonging to the coal-field of South Wales as given in Geikie's "Textbook of Geology," 2nd edit., 1885, p. 742, are (for Glamorganshire):—

Upper series: sandstones, shales, etc., with 26 coal-seams, more than	3400 feet.
Pennant grit: hard, thick-bedded sandstones, and 15 coal-seams ...	3246 ,,
Lower series: shales, ironstones, and 34 coal-seams	450 to 850 ,,
Millstone grit.	

The Coal-measures are thus estimated at 7496 feet, or nearly 1½ mile in thickness, besides the Millstone-grit and the Carboniferous or Mountain Limestone occupying a still lower position.

Differences of observation or of opinion from time to time have caused different estimates. In 1855 Professor J. Phillips, who took a very strong interest in the geology of the coal-fields, published the following measurements (in his "Manual of Geology," 1855, p. 201) as representing only a general view, and he indicated that nearly 12,000 feet thickness may occur near Llanelly:—

Llanelly series, with several beds of coal	1000 feet.
Penllergare series of shales, sandstone and beds of coal—110 beds; 26 beds of coal	3000 ,,
Central series (Townhill sandstones of Swansea = Pennant-grit of the Bristol coalfield)—62 beds; 16 beds of coal	3246 ,,
Lower shales, coals, and ironstones (Merthyr)—266 beds; 34 beds of coal	812 ,,
	8058

Farewell Rock and Gower Shales, above the Carboniferous Limestone.

Professor Hull[3] gives about 1200 to the Coal-measures, with twenty-five seams of coal of two feet thickness and upwards; making a total of eighty-four feet of workable coal. In 1881 Professor Hull calculated that there remained about 32,166 millions of tons of available coal, which might possibly last for more than 1000 years at the present rate of consumption.

Mr. E. Rogers, in the "Memoirs of the Geol. Survey: Iron-Ores," part iii. 1861, p. 169, divides the Coal-measures of South Wales into an Upper and a Lower series, with the hard siliceous sandstone (locally a conglomerate), known as 'Cockshute' and 'White Rocks' between them. The upper measures, he says, are mostly micaceous sandstones, locally known as

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[1] *Ibid*, chap. i.

[2] Etheridge, 1885. p. 238.

[3] "The Coalfields," etc., 1881, p. 108.

'Pennant Rocks.' The lower series is sometimes termed the 'iron-bearing measures,' as it contains the bulk of the ironstone as well as coal, which is bituminous on the east and gradually less and less bituminous westward, until after passing the great dyke or fault in the Vale of Neath it becomes anthracite. The upper series contains few iron-ores, and the coal is bituminous, even when anthracite exists below it, as in the Swansea district and elsewhere.

In his communication to the British Association in 1837,[1] Sir W. E. Logan stated that "the non-bituminous coal, or stone-coal, is found on the north side and at the west end; the bituminous coal on the south side and east end; and that there is an intermediate region occupied by an intermediate quality." These conditions of the coal-seams indicated to Logan "the possibility of a rule in the change of quality—namely, that it occurs in parallel planes, cutting the seams of coal without regard to their strike or inclination, and dipping to the south or east of south."

These coals begin to became anthracitic at Rhymney; and the change becomes gradually more and more marked as we pass by Dowlais, Cyfartha, Hirwain, Onlwyn, and Neath Valley, to the Swansea Valley,[2] according to analysis given by Mr. David Mushet in the Appendix to his "Papers on Iron and Steel," 8vo. London, 1840. At page 68 of this book Mr. Mushet notes that "in South Wales as the coals approach the anthracite district they are found to contain 90 per cent. (of carbon), with no more flame than is necessary to convert the coal into coke."

Mr. Etheridge (1885) accepts (p. 238) Professor Phillips's foregoing table; but he also arranges the coal-bearing portions as divisible into—1. Upper Pennant series; 2. Lower Pennant series; 3. White-ash series; and gives the following plan in addition:—

1. Upper or Penllergare series, more than	3400 feet.
2. Pennant-grit (Swansea)	3246 „
3. Lower Coal-measures	450 to 850 „

At p. 219 he reviews the whole of the series as—

Coal-measures	11,000 feet.
Millstone-grit ('Farewell Rock')	300 „
Yoredale Rocks ('Gower Shale')	1,600? „
Scar Limestone	1,900 „
Lower Limestone Shales	400 „
	15,200

making the Coal-measures more than 1½ mile thick, and the whole series more than 2½ miles.

(*To be continued in our next Number.*)

II.—Report of the Committee, consisting of Dr. John Evans (Chairman), Mr. B. Harrison (Secretary), and Professors J. Prestwich and H. G. Seeley, appointed to carry on excavations at Oldbury Hill, near Ightham, in order to ascertain the existence or otherwise of Rock-shelters at this spot. Drawn up by Mr. B. Harrison.

OWING to hindrances, the work could not be begun until August, 1890. The first excavation, immediately below the exposed rocks, was unproductive in a great measure. This was owing to huge trees being close by, the roots of which, forming a perfect network, offered serious obstacles, as, though permission had been granted by the owner to excavate, yet damage to the trees was strictly forbidden.

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[1] "Report," 1838, Trans. Sec. p. 85.

[2] Bevan, "Geologist," vol. ii. 1859, pp. 78, 79.

A section was first cut parallel with the face of the rock, but no true floor was reached, the rock itself being too near the surface, and forming merely a shoulder under the surface soil.

Many days at this being unsuccessful, another excavation was made on the slope of the hill just below, and a considerable area was trenched to a depth of about 3 feet.

Here, however, only Neolithic flakes were found; and great blocks, fallen from above, and deeply embedded in the soil, presented obstacles not easy to surmount. Later on work was commenced lower down still, at a spot where, in cultivating the ground in former years, relics of Palæolithic age had been found.

Two implements were secured, but the rocky conditions tried my labourers' strength; and to do the work thoroughly horse-power was needed, the blocks in many instances weighing more than half a ton. A good large area, however, was here trenched to a depth varying from 3 to 5 feet.

The slope of the bold projecting spur below Mount Pleasant, lying about fifty yards south-east of the former digging, was next tried, and here success crowned our efforts, for very soon immense numbers of flakes were met with, and in such profusion that I was prompted to carry on the work thoroughly.

Leave was asked for and granted for an area of some 9 or 10 rods to be worked over, and ere long finely fashioned characteristic Palæolithic implements were found daily, as well as flakes, some of these so minute that it seemed as if the actual workshop had been lighted on. Altogether 49 well-finished implements, or portions of them, and 648 waste flakes, have been found at this spot, leading to the supposition either that this was the frontage of a rock-shelter, or that the material had slipped down from above. We think that it would be highly desirable to make further excavations in this and the adjacent area.

The great portion of these flakes were found at depths varying from 2½ to 3 feet; and, as a rule, they lay at the base, and immediately overlying a gravelly wash. The implements are very similar to some of those found in the rock-shelters of Central France.

Similar conditions to those of this spur appear on the north-west side of Oldbury Hill, near to an outcrop of rock; and at various times implements have been found near by.

Leave has been granted for work to be carried on here.

III.—Report of the Committee, consisting of Mr. J. W. Davis (Chairman), Rev. E. Jones (Secretary), Drs. J. Evans and J. G. Garson, and Messrs. W. Pengelly, R. H. Tiddeman, and J. J. Wilkinson, to complete the Investigation of the Cave at Elbolton, near Skipton, in order to ascertain whether Remains of Palæolithic Man occur in the Lower Cave Earth.

THE Elbolton Cave Exploration was continued under the direction of your Committee until the end of December, 1890. The entrance to the cave is through a shaft or pot-hole 20 feet in depth situated at the foot of a small limestone scar on Elbolton, 1000 feet above sea-level. The chamber, before the exploration commenced, was 30 feet long, and varied from 7 to 13 feet in width. The floor was fairly level, with the exception of a heap of stones under the entrance. On the surface nothing was observed but a few sheep bones of recent origin. The upper stratum, which varied in thickness from 4 feet at the east to 17 feet at the west end of the chamber, is the only one wherein human remains have yet been found. It consisted of loose angular fragments of limestone interspersed with large quantities of bones of the Celtic Shorthorn, the Horse, the Boar, Dog, Red Deer, Sheep, etc. The bones of the larger animals were split and broken, and were evidently used as food. Burnt bones and charcoal were found in three places. Three human skeletons were discovered buried with the legs bent and the knees close to the skull. The other human bones were more or less scattered. Most of the skulls were shattered, though two, obtained from the east end, are fairly preserved, and are good typical specimens of the *long head* type. But the human remains obtained from the other end of the chamber and at a much lower level, 13 and 15 feet below the floor (one lying but a few inches above the clay containing the bones of the Bear and Reindeer), are not dolichocephalic but brachycephalic. The latter are more decayed than the others. Associated with the round head was pottery of different character to that which was found in other parts of the cave. It is thicker, ruder, and with a different ornamentation. The pottery found near the long-headed men was marked with straight lines, in some cases cutting one another and forming a diamond-shaped ornamentation, in others going in and out without intersecting, forming a 'herring-bone' pattern. Others had impressions made by some rounded bone tool. But the pottery found near the remains of the round head is ornamented with wedged-shaped characters made with an angular tool. Both kinds of pottery were made from clay similar to that found in the cave, and both kinds were hand-fashioned without wheel, and charred and burned from the inside. No flints or metal of any kind have been found in the cave. The only objects obtained have been bone pins and a few other worked bones.

From the position where this brachycephalic skull was found, and from the ruder kind of pottery associated with it, it would appear that in Craven a round-headed race preceded the long-headed one.

Nearly all of the upper stratum containing human remains had been cleared away before August last, and the next layer had been worked for some distance, especially in the second shaft at the west end of the chamber. So far this lower stratum was composed of stiff clay, with angular fragments of limestone, and at times a thin bed of stalagmite. No human remains nor any of the animals associated with them have been found. These are replaced mainly by Bears, both *Ursus ferox* and *Ursus arctos*, and great numbers of Alpine Hares and Foxes. The bones in this layer show no evidence of having been gnawed by other animals; they either perished in the fissure or their bones were washed down through pot-holes into the cave. The bones from the lower layer are darker, much harder, and less porous than those from the upper one.

After the meeting of the Association at Leeds the efforts of your Committee were first directed to the careful examination of the lower clay bed in the centre of the chamber. A pot-hole, about 10 feet deep and 3 feet in width, was cleared out. This contained a few of the limb bones of a Bear. A great part of the rock floor at the foot of the first ladder was blasted. It consisted apparently of a quantity of rock fallen from the roof and cemented by stalagmite. We were hopeful that underneath it we should find an old deposit. So far, however, it is solid. Further west the excavation was continued, the difficulty of working in the soft adhesive clay increasing. The percentage of bones was small, and in the next six feet not a single bone was found. The cave has now developed into a deep fissure, and is from 4 to 6 feet in width at a depth of about 45 feet from the original level of the cave floor. The attention of your Committee was next directed to find any possible entrance to the cave in addition to the present one: the floor was tested along the sides of the cave east of the first ladder, but the miners report that there the ground was all solid rock.

Between the barren clay section and the second ladder there is a quantity of unexplored material. Huge blocks of fallen rock are wedged in the fissure, and it was found unsafe to remove them as they underpin an immense overhanging side of the cave 60 feet in height. The second ladder was then descended, and a level driven beneath the fallen blocks at a depth of 45 feet from the first floor. For the first 6 feet this level was as ossiferous as any of the material yet examined, and of similar character, containing bones of the Bear and Hare. Beneath was a barren clay, followed by beds of sharp quartz sand, until the level is barred by solid rock. In the descent two or three stalagmitic floors were pierced, but the material continued the same above and below the stalagmite. The new chambers that were opened last year are extensions of this fissure. The miners have put a steel rod 8 feet lower than present level, forcing it through another stalagmitic floor. While the east part of this level is sand, containing no bones, the western part and the passage up to the new chamber is a brecciated mass of bones and stalagmite.

At the further extremity of the new chambers, and about 60 yards from foot of second ladder, there was a deep pool into which the roof dipped. In the floor of the passage leading to the pool a hole 8 feet deep was dug. The material was comminuted limestone. Here also bones of young Bears were found. They had evidently been washed down from the first chamber. By means of this excavation the pond was lowered 4 or 5 feet. A ladder was placed across it, and an entrance effected into a further passage leading to a large natural chamber.

So far the cave has been interesting. What may be entombed in the unexplored depths of the fissure is a matter of pure conjecture. Whether a repetition of the finds in the fissure at Ray Gill, and in the lower cave earth of the Victoria Cave, with the addition of Palæolithic man, must be left for future exploration to determine.

Your Committee request reappointment, and that a grant of £25 be made to assist in the further exploration of the cave.

CORRESPONDENCE.

NOTES ON CONISTON FLAGS.

Sir,—May I be allowed to point out that in my "Note on the Coniston Flags" in your last issue, the printer makes it appear that in microscopic work I made use of sections rather larger than are usually employed. Speaking of the garnets (p. 460), he makes me say that this mineral appears and disappears "within a few yards *along* the slide and a few feet *across* it."

Messrs. Voigt and Hochgesang, who make my sections for me, have very great skill in our work, but I do not think they could quite make slides of the size here indicated! What I wrote was *strike*, where the printer has put *slide*. W. Maynard Hutchings.

Newcastle-on-Tyne, *Oct.* 7, 1891.

CONCRETIONS IN MAGNESIAN LIMESTONE.

Sir,—Has not Mr. Garwood omitted to consider a third possible method of origin for these and similar concretions? Infiltration and Segregation are not the only ways in which concretions are formed. Why should not the carbonate of lime have been obtained from the water above, while that particular bed was being deposited? It is not necessary to suppose that the carbonate of lime must have been deposited in the bed and then segregated; it is surely more likely that it was in solution in the water above, and was precipitated by chemical action. The ammonia or ammoniacal compounds evolved from decaying organic matter might be the initial cause.

A. J. Jukes Browne.

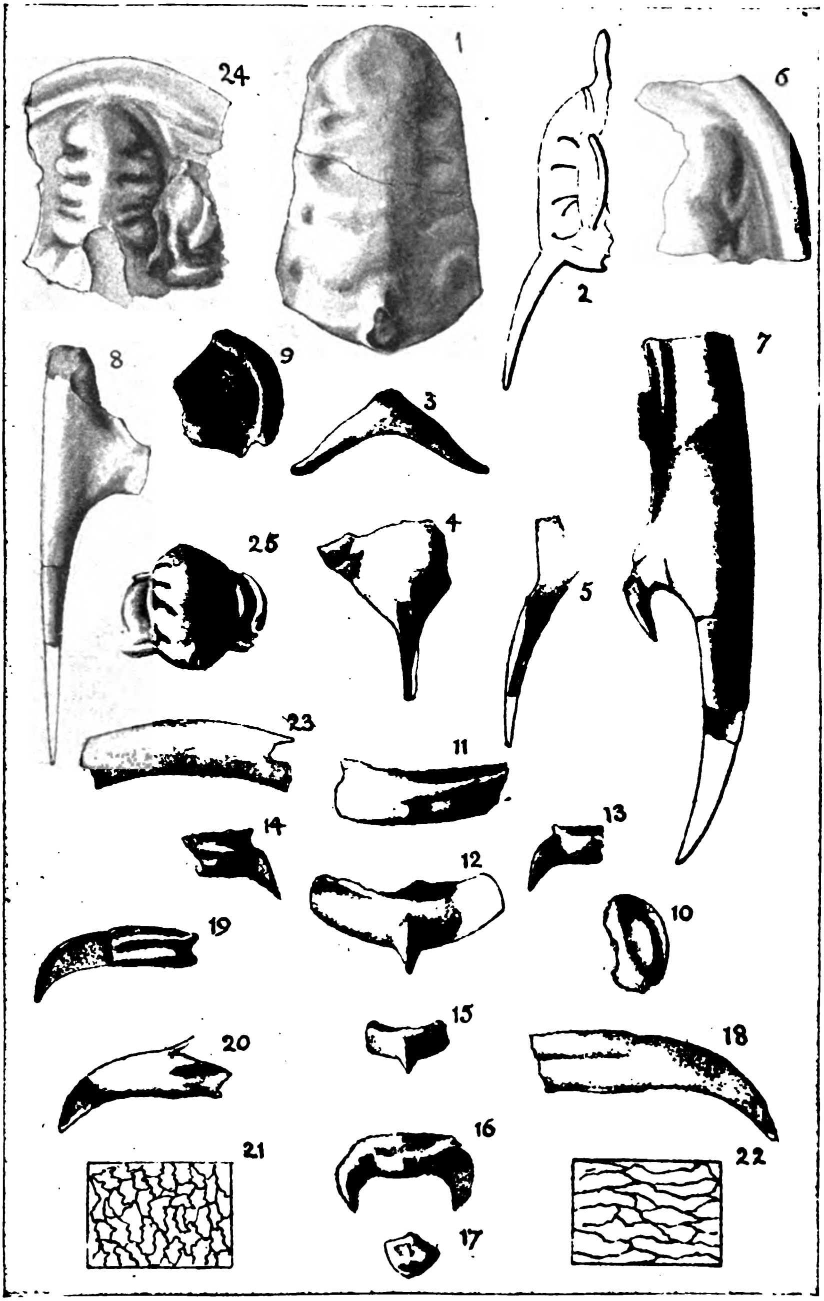
OBITUARY.

With deep regret we record the following deaths:—

Charles Smith Wilkinson, F.G.S., F.L.S., V.P.L.S., N.S.W., the Government Geologist for New South Wales, who died at Sydney on 23rd August, 1891, aged 47 years.

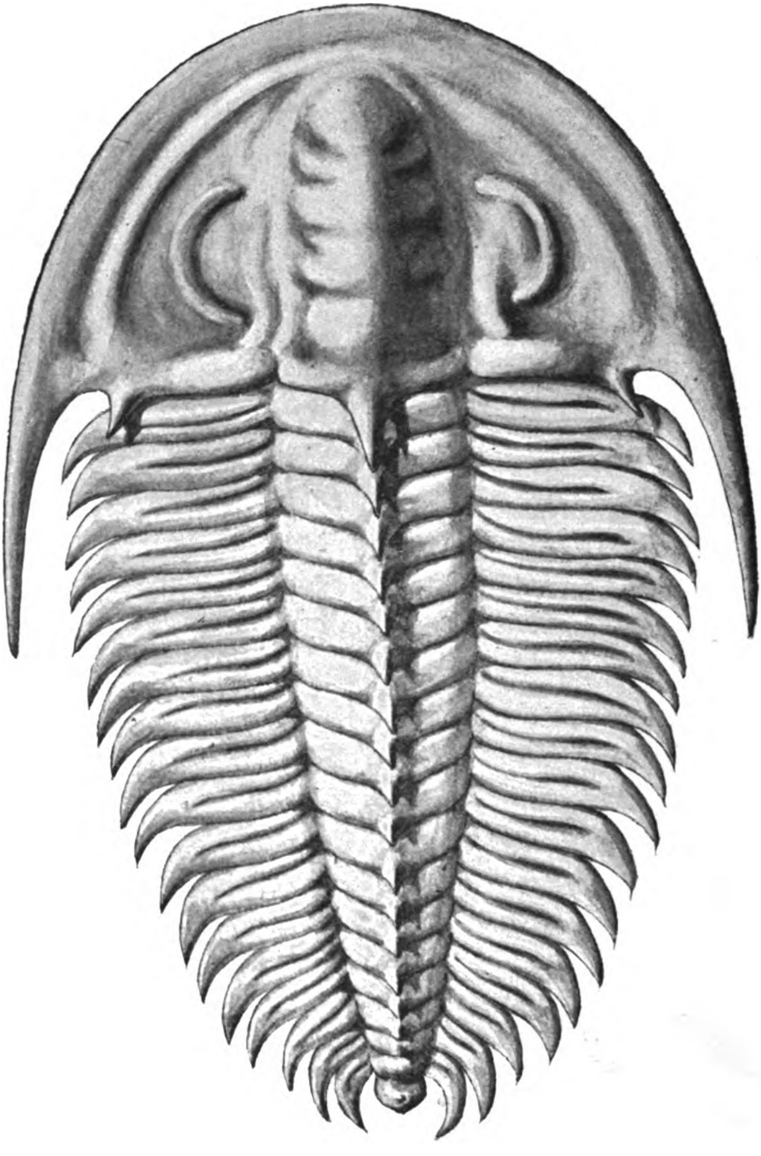
Philip Herbert Carpenter, D.Sc. (Camb.), F.R.S., F.L.S., Science-Master of Eton College, who died on 21st October, 1891, aged 39 years.

We hope to publish a fuller notice of these eminent geologists and palæontologists next month.



E. C. Woodward, del. Messenbach Co. sc.

Olenellus Callavei, Lapworth,
from the Comley, or Hollybush Sandstone, of Shropshire.



Olenellus Callavei, Lapworth,

Comley, or Hollybush Sandstone of Shropshire.

Theoretical restoration, natural size.

THE

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NEW SERIES. DECADE III. VOL. VIII.

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ORIGINAL ARTICLES.

I.—ON *OLENELLUS CALLAVEI* AND ITS GEOLOGICAL RELATIONSHIPS.

By PROF. CHARLES LAPWORTH, F.R.S.

(PLATES XIV. AND XV.)

IN the year 1888 I published a short paper in the pages of the GEOLOGICAL MAGAZINE[1] and in "Nature,"[2] in which I gave a brief account of the discovery of the fauna of the *Olenellus* (or Lower Cambrian) zone in the Comley or Hollybush Sandstone of Shropshire. Since that date great advances have been made in our knowledge of the *Olenellus* fauna of other areas, and the *Olenellus* zone has now generally attained an established rank and systematic position in the Geological Record as the basal zone of the Cambrian system.

At the time my paper was written sufficient material had been obtained to enable me to recognize the existence of a well-marked species (*Ol. Callavei*) of the genus *Olenellus* in the Comley Sandstone series. But the form appeared to be so closely allied to the *Olenellus Bröggeri*, which had been discovered by Mr. Walcott,—the distinguished palæontologist of the United States Geological Survey—in the basement beds of the Cambrian of Newfoundland, and exhibited and named by him at the meeting of the Geological Congress in London in 1888, that, as I explained in the paper referred to, I felt that it was but just that I should await the appearance of the formal description of his species before publishing my own.

Thanks to the kindness of Mr. Walcott, his brilliant and long-expected Monograph "On the Fauna of the *Olenellus* Zone"[3] now lies before me, in which *Olenellus Bröggeri* is admirably figured and described; and although it includes a comparative diagnosis of *Olenellus Callavei*, sufficient for registration and identification, I take this my first possible opportunity of figuring and describing in full our Shropshire form, that the want of acquaintance with its minor specific characters may not delay those who may be desirous of publishing new species from the *Olenellus* zone elsewhere.

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[1] Lapworth, "On the Discovery of the *Olenellus* Fauna in the Lower Cambrian Rocks of Britain," GEOLOGICAL MAGAZINE, 1888, Dec. III. Vol. V. p. 485.

[2] "Nature," vol. xxix. p. 213.

[3] See next page.

The fragments figured on Plate XIV. are those which were exhibited by myself at the meeting of the Geological Congress at London in 1888, supplemented by a few others which were at the time in my possession. The majority were collected by Mr. H. Keeping (acting under my instructions with the kindly consent of Prof. T. McKenny Hughes, F.R.S.) during the previous years, and are the property of the Woodwardian Museum, Cambridge.

The restoration attempted on Plate XV. is founded essentially upon these fragments; so that palæontologists will be able to judge for themselves in what respects that restoration is justified or defective.

OLENELLUS (HOLMIA) CALLAVEI, Lapw.

Plate XIV. Figs. 1–25. Plate XV. Fig. 26.

1888. *Olenellus Callavei*, Lapworth, GEOLOGICAL MAGAZINE, Dec. III. Vol. V. p. 485.
1888. *Ibid.* Lapworth, "Nature," vol. xxix. p. 213.
1889. *Olenellus Callavei*, Walcott, American Journal of Science, vol. xxxvii. p. 391.
1891. *Olenellus* (*Holmia*) *Callavei* (Lapw.), Walcott, "Fauna of the *Olenellus* Zone," 10th Report Geol. Survey, U.S.A., pp. 640–641, p. 581, etc.

Description.—General form ovate-elliptical, about one and a half times longer than broad. Head broad, semi-circular to semi-elliptical in outline and moderately convex. Margin edged exteriorly by a broad conspicuous rounded rim or flange, and limited interiorly by a faint parallel angular ridge. Posteriorly the margin is broadened and prolonged in a strong rounded spine. The under side of the proximal margin forms a broad rounded doublure. The posterior margin of the head bears two short, stiff, spur-like "interocular" spines, which are directed backward and outward, and are continued interiorly by a faint ridge which appears to be prolonged almost to the crest of the glabella in advance of the occipital furrow.

Glabella broadly convex in elevation, and sub-clavate in outline; attaining its greatest width near the anterior extremity of the eye-lobe, and having a sharply rounded to sub-triangular frontal edge. It is furnished with three pairs of glabellar furrows (with traces of a fourth anterior pair). They occur as shallow and broad double depressions, deepest midway between the axis and the lateral margins, and almost disappearing as they cross the central parts of the glabella. Occipital furrow of the same type as the rest; but broader and deeper, and limited in part anteriorly by a slight but conspicuous ridge (the proximal extension of the "interocular" process?). Occipital ring flat and narrow laterally; rising posteriorly to a strong marginal rim, and rapidly increasing in width and height to its centre, where it insensibly graduates into a stout claw-like spine, which arches backward over the first two (?) segments of the thorax.

Eye-lobes prominent, elongate, narrow, lunate to semi-circular, situated sub-centrally with respect to the height of the glabella; arching outward from the base of the anterior lobe to a distance equal to half the width of the glabella, and backwards almost to a line with the occipital furrow. Visual surface unknown. Area between glabella and eye-lobe flat, and separated from the glabella by an irregular undulating groove. Frontal limb narrow. Surface of free cheek slightly convex, sloping inwards to the eye-lobe, and outwards to the groove bounding the lateral margin. Thorax with 18 (?) segments. Axial lobe elevated; prominently rounded and narrowing throughout. Each axial segment is well defined. It is thickened posteriorly and laterally grooved; and it bears centrally a short and stout recurved claw-like spine, with a spreading base, and a sharp ridge-like upper surface. The terminal segments bear in addition two lateral rudimentary spurs, while the central spine is much reduced in size. Pleural lobes, flattened for the first half to two-thirds of their length; and then gracefully curving and contracting to the recurved falcate extremity. The proximal surface of each is relieved by an oblique pleural groove.

The associated pygidium is small, simple, almost semi-circular in form; with slightly converging lateral margins, straight and shortened posterior edge, distinct central elevation, and anterior groove.

The test or body-covering of both head and thorax is marked throughout by a raised fretwork of inosculating lines or ridges, the pattern of which varies in different parts.

Dimensions.—The larger fragments collected indicate a length of about six inches and a breadth of about four inches. With the exception of *Olenellus* (*Holmia*) *Bröggeri*, Walcott, this form is the largest species of the genus yet discovered.

Comparisons.—*Olenellus Callavei*, as I have already more than once pointed out,[1] is most intimately allied to *Olenellus Kjerulfi*, Linnarsson, from the Lower Cambrian of Norway, and *Olenellus Bröggeri*, Walcott, from the basal beds of the Cambrian of Newfoundland. These three species appear to me to constitute a special subgeneric (?) group, intermediate between *Olenellus*, Hall (including *Mesonacis*, Walcott, and *Olenoides*, Meek). They all possess the remarkable "interocular" processes and conspicuous dorsal spines of the latter, but differ in the absence of the facial suture. They agree with *Olenellus* (including *Mesonacis*) in the general form of the head and of the glabella, and in the peculiar ornamentation of the test; but differ in the absence of the great median or terminal spine. From both groups they are strikingly distinguished by the great development of the occipital process. In allusion to this common characteristic feature, I suggested for the group the title of *Cephalacanthus*;[2] but, as Mr. Walcott has pointed out, this term must give way to *Holmia*, the subgeneric title published by Mr. Matthew[3] in June, 1890, for *Olenellus* (*Holmia*) *Kjerulfi*, Linnrs., the first discovered species of the group.

Olenellus Callavei not only agrees with *Ol. Kjerulfi* in its general characters, but in the conspicuous development of the interocular spines, in the existence of a faint ridge sweeping back from the spine almost to the axis of the glabella just in advance of the neck furrow; in the double character of the lobes and furrows of the glabella itself, and in the form and position of the eyes. It differs from *O. Kjerulfi* in its larger size, and more compact habit; in the rapid contraction of the glabella towards the front, in the much greater development of the occipital spine, and in the falcate character of the terminal parts of the pleuræ.

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[1] Geol. Mag. etc., *loc. cit. supra.* Fauna *Olenellus* Zone, pp. 640–641.

[2] Geol. Mag. 1888. p. 641.

[3] Matthew, Trans. Roy. Soc. Canada, 1890, p. 160.

O. Callavei agrees, on the other hand, with *Ol. Bröggeri* in all those features which distinguish the former from *O. Kjerulfi*; and differs from it in all those characters which are common to the English and Norwegian forms. In addition, a minor distinction is constituted by the much greater extension of the genal and interocular processes in *O. Callavei* than in *O. Bröggeri*, and a much lesser extension of the great occipital spine.

The form is dedicated to my friend Mr. Charles Callaway, D.Sc., F.G.S., who was the first to detect organic remains in the Comley Sandstone, and the first to demonstrate the presence of true Cambrian fossils in Shropshire generally; and whose original and sagacious inference as to the probable pre-Cambrian age of the unconformably underlying rocks the discovery of *Olenellus* places beyond much dispute.

In addition to the fragments upon which the foregoing description has been mainly drawn up, a few figures (Figs. 24 and 25) are given on Plate XIV. of younger examples of the species, in which the same characteristic features will be recognized.

Olenellus Callavei occurs in a highly calcareous bed of bright purplish-red calcareous sandstone, or sandy limestone, near the base of the Comley Sandstone (Hollybush) series of Central Shropshire. The figured specimens were all procured from a single locality—the Comley Quarry—at the foot of the hill of Little Caradoc, near Church Stretton. In this district the *Olenellus*-bearing sandstone *passes down* into olive-green felspathic flags, grits, and concretionary shales, and the base of the entire Comley Sandstone series is formed of the well-known Caradoc or Wrekin Quartzite, which reposes unconformably upon the Volcanic Uriconian Group of Callaway. The *Olenellus*-bearing beds are *overlain* at once by conglomerates, and gritty and quartzose strata, containing abundant fragments of igneous rocks, concretions of carbonate of copper, calcareous bands, and limy nodules; and these in turn pass up into flaggy shales and quartzose grits, forming the highest visible parts of the Comley series.

Olenellus Callavei appears to be strictly confined to that part of the Comley series which lies below the conglomerate bands mentioned above; and its associates include *Kutorgina cingulata*, *Linnarssonia sagittalis*, *Hyolithellus* (compare *H. micans*, Walcott) and *Elliptocephalus*, sp.

The overlying conglomerates and limestones are distinguished by the presence of a large species of *Paradoxides* (*P. Groomii*[1] sp. nov.), together with forms of *Ptychoparia*, *Obolella*, *Protospongia*, etc.

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[1] *Paradoxides Groomii*, sp. nov. In general form and size intermediate between

The generic position of the two characteristic forms of the Lower and Upper Divisions of the Comley Series being thus settled, the descriptions of the less important associated forms may conveniently be deferred to a more favourable occasion.

We possess in the foregoing facts sufficient palæontological evidence to establish the Lower Cambrian age of that part of the Comley series which contains the genus *Olenellus*; and we have now obtained stratigraphical and palæontological proof that it is succeeded at once by the so-called Middle Cambrian or *Paradoxidian*. Further, as Dr. Callaway[1] originally pointed out some years ago, the Hollybush (or Comley Sandstone) series is followed in turn by the Shineton Shales, which contain locally a fauna of highest Cambrian age. In these Central Shropshire rocks, therefore, the Comley and Shineton Groups, which constitute an integral part in this district of Murchison's original *Lower Silurian*, and have a collective thickness of perhaps less than 3000 feet, we have apparently a condensed epitome of the entire Cambrian system as at present generally defined.

Here, as elsewhere, we find the Cambrian divisible into three sections—an Upper Cambrian above, marked by the presence of the genus *Olenus* (Olenidian); a Middle Cambrian group with *Paradoxides* (Menevian or Paradoxidian); and finally a Lower Cambrian (*Olenellus* zone) or basal group (possibly of somewhat different systematic importance), distinguished by the presence of *Olenellus*. No one has yet, so far as I know, suggested any general title for the basal division of the Cambrian. Recollecting, however, that the very first discovered species of the genus *Olenellus* was named and figured[2] by the American geologist, Dr. Emmons, as early as 1846 from the rocks of his Taconic or Taconian system; and was claimed by him as early as 1853[3] as coming from strata older than any of the fossil-bearing Silurian (including the Primordial zone) then discovered; while even at the present day the genus holds its own as marking a distinct and identifiable life-zone in the strata of Emmons' typical Taconic area; it would be very convenient if geologists and palæontologists generally would agree in calling it the Taconian.

In my short paper already referred to, "On the Discovery of the *Olenellus* Zone in Britain," I drew a few provisional inferences, novel at that time, but thrown out then as "constituting a provisional working hypothesis, of service mainly as a guide and

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Par. Harlani (Green) and *Par. Davidis* (Salter). Length 8 to 9 inches, breadth 5½. *Head* semi-circular, with pointed genal spines from two to three inches in length. *Glabella* prominent, clavate, more than half its length being occupied by the broadly rounded and smooth frontal lobe. *Hypostoma* of the type of that of *Par. Bohemicus* (Boeck). *Pleuræ* (no ?) falcate, and sharply pointed. Pygidium a raised disc with central tubercle; embraced laterally by long, sabre-like, distally-diverging spines. *Localities*. Neves Castle (Lapw., 1889) and Comley (Groom, 1890). Named after T. Theo. Groom, Esq., B.Sc., who first collected fragments sufficient for description.

[1] C. Callaway, "Upper Cambrian Rocks in South Shropshire," Q.J.G.S. 1877, p. 652, etc.

[2] As *Elliptocephala asaphoides*, Emmons, Taconic System, 1846, p. 213, figs. 1, 2, 3.

[3] Emmons' American Geology, 1855, pt. ii. pp. 6 and 7, etc.

stimulus to future discussion, investigation, discovery and correction." It is somewhat instructive to note how—taking the publication of these provisional inferences as our starting point—geological knowledge and opinion in this department has advanced in the interval. These theoretical conclusions were three in number, and for the sake of comparison—the contrasts between them (as paraphrased from their original crude form), and their present aspect (in so far as can be deduced from the actual state of geological opinion),—may very briefly be summarized as follows:—

(*a*) The presence of *Olenellus* in these Shropshire strata appears to fix the pre-Cambrian age of the Uriconian Series of Dr. Callaway, and to render the pre-Cambrian age of his Longmyndian a matter of fair probability.

Since 1888, Professor Blake, who has of late years added very much of great value to our knowledge of the Cambrian and pre-Cambrian rocks, unhesitatingly assigns the lower zones of the Longmynd Series of Callaway to his own Monian, or pre-Cambrian.[1] Sir A. Geikie, after studying the *Olenellus*-zone and the overlying and underlying rocks in the field, has frankly expressed his view that the Uriconian may be of pre-Cambrian age.[2] Finally, the fact brought forward in the present paper—namely that representatives of all three divisions of the true Cambrian, as at present acknowledged, are actually known to occur in Central Shropshire, being mapped as constituting an integral part of Murchison's original Lower Silurian,—renders it very unlikely that the Longmyndian (the original pre-Silurian or Cambrian of Murchison and the other great stratigraphists who immediately followed him) can be anything else than pre-Cambrian.

(*b*) The so-called Upper Cambrian of the Malverns, Central England and N.W. Scotland may be in reality a greatly attenuated representative of the entire Cambrian system; part of an originally fairly continuous Cambrian once extending from Lapland through Britain and Europe to Sardinia—and the Sardinian and Durness formations may both range down to the base of the Cambrian.

The recent brilliant discovery of *Olenellus* by the officers of the Geological Survey of Scotland,[3] in the Fucoid and Salterella zone, in the lower parts of the Durness-Eriboll Series, establishes the correctness of this suggestion for the N.W. Highlands. The detection of *Paradoxides Groomii* in the supra *Olenellus*—infra *Olenidian*—zones of Central Shropshire, as described in the preceding pages of the present paper,[4] appears to settle the matter equally satisfactorily as regards Southern Britain:—

(*c*) If so the Torridon Sandstone of North West Scotland would possibly go with the Longmyndian into the pre-Cambrian, the Schists of St. Lo in France, and the rocks of corresponding antiquity elsewhere.

Here, again, this provisional conclusion has been extended and left far behind by later research and opinion. As already pointed out by Sir A. Geikie,[5] the discovery of *Olenellus* in the Durness-Eriboll

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[1] J. F. Blake, On the Monian and Basal-Cambrian Rocks of Shropshire, Q.J.G.S. 1890, p. 386, *et. seq.*

[2] Sir A. Geikie, Anniversary Address, Q.J.G.S. 1891, pp. 86–90.

[3] Sir A. Geikie, GEOL. MAG. 1891, p 449.

[4] See *ante* p. 532.

[5] *Ibid.* p. 449.

Series fixes the pre-Cambrian age of the Torridon Sandstone. Again, Dr. Katzer[1] has shown that the strata of the Bohemian Urgeberge (the Cambrian[2] of Barrande and Murchison—Etages A. and B.) lie (at least locally), unconformably below the rocks of the true Cambrian or Primordial zone (a conclusion recently confirmed by Dr. Wentzel[3]) and must, therefore, be now classed as pre-Cambrian or Archæan. In precisely the same way in two recent and most valuable memoirs by M. Bergeron and M. Bigot we are presented in one area (N.W. France) with clear physical proofs,[4] and in another (Languedoc) with actual palæontological evidence,[5] that the condensed Cambrian of Central Britain is apparently prolonged through France from the Channel Isles to the Montagne Noire; and as a consequence the underlying (often unconformable) schists of St. Lo, etc.—*i.e.* the Cambrian of Dalimier, Dufrenoy and Murchison—may now be regarded as of Archæan or pre-Cambrian age.

Thus while we have still very much to learn respecting the fossils, the component members, and the local development of the ancient Palæozoic strata, and while we must admit that many of our present inferences and conclusions lie open to improvement and correction by future investigation and discovery—the students of these old rocks (however much they may conscientiously differ in the provisional nomenclature in which they clothe their facts) have now all more or less attained to the conviction that we are at last reaching a satisfactory homotaxial base to the Palæozoic rock-series. We now see that the Lower Palæozoic cycle of formations (the Protozoic or Protogean) or the Silurian of Murchison's '*Siluria*' and Barrande's '*Système*' has proved itself to be a geological cycle of the first order. We agree, in principle, that it is made up (like each of the succeeding great cycles), of three sub-equal groups[6] or systems—an Upper system (the *Silurian* proper, or *Salopian*) a Middle system (the *Ordovician*) and a Lower system (the *Cambrian*). This lower system, like each of the two systems above it, has now shown itself divisible in its turn into three sections—an Upper Cambrian (*Olenidian*), a Middle Cambrian (*Paradoxidian*) and a Lower Cambrian (*Taconian*).

Underneath this Cambrian lie sometimes conformably, sometimes unconformably, the strata of the mysterious cycles of the Pre-Cambrian (or Archæan). Of these, certainly the rocks of the unaltered divisions (the Eozoic or Eogean cycle) are now so well circumscribed geographically that there appears little to hinder their detailed study and investigation by an extension and development of the same rules which have been employed in satisfactorily determining the order and the characteristic organic remains of the more recent systems. Surely it is not too much to hope that the day is fast approaching when these Eozoic formations will be reduced to their natural order as fossil-bearing systems, comparable in all respects (except in the greater paucity of their organic remains) with the Post-Archæan systems which at present form the accepted members of our great geological scale.

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[1] Dr. Fr. Katzer, Das ältere Palæozoicum in Mittel Böhmen, Prague, 1888, pp. 5, 7.

[2] Siluria, 4th edition, p. 273.

[3] Dr. Josef Wentzel, Die Beziehungen der Barrandischen Etagen C, D, E zum Britischen Silur., Jahrbuch d. k. k Reichsanstalt, Wien, 1891, p. 119.

[4] A. Bigot, L'Archéen et le Cambrien du Massif Breton, Cherbourg, 1890, pp. 25, 73, etc.

[5] J. Bergeron, Etude géologique du Massif ancien du Plateau Central, Paris, 1889, p. 78, pl. ii.

[6] The *Silurien supérieur*, *Silurien moyen*, and *Silurien inférieur* respectively, of the younger French geologists.

EXPLANATION OF PLATE XIV.

Fig. 1. *Olenellus Callavei.* Glabella in relief, showing the characteristic shape, the lobes and furrows, and the broken base of the occipital spine.
Fig. 2. ——— ——— Do. Side elevations.
Fig. 3. ——— ——— Occipital lobe with base of central process. Posterior aspect.
Fig. 4. ——— ——— Fragment of hinder part of glabella, etc., from above, showing size and length of a broken occipital spine.
Fig. 5. ——— ——— Do. Side elevation.
Fig. 6. ——— ——— Fragment of part of head, showing marginal and interior ridges.
Fig. 7. ——— ——— Terminal part of free cheek with marginal ridge, and genal and "interocular" spines.
Fig. 8. ——— ——— Do. Another and smaller example.
Fig. 9. ——— ——— Eye lobe.
Fig. 10. ——— ——— Do. Smaller example.
Fig. 11. ——— ——— One of the anterior segments of the axis, showing the form and position of the median spine.
Fig. 12. ——— ——— Do. From central parts of axis.
Fig. 13, 14. ——— ——— Do. Profile views.
Fig. 15. ——— ——— Segment of axis near posterior end.
Fig. 16. ——— ——— Sub-terminal (?) segment of axis, showing central and lateral tubercles.
Fig. 17. ——— ——— Pygidium.
Fig. 18. ——— ——— One of the proximal pleuræ, showing general form, pleural groove, and falcate extremity.
Fig. 19, 20. ——— ——— Pleuræ from near posterior end of thorax.
Fig. 21. ——— ——— Superficial ornamentation of test. (Magnified.)
Fig. 22. ——— ——— Ditto. (Magnified.)
Fig. 23. ——— ——— Doublure for attachment of hypostoma.
Fig. 24. Young form of *O. Callavei*, showing general form and characters of the glabella, eyes. frontal margin, etc.
Fig. 25. Do. Another example.

(All the fragments figured, except Figs. 21 and 22, are of the natural size.)

Figs. 18, 19, 20, 24, are from my own Collection, the remainder are in the Collection of the Woodwardian Museum, Cambridge.

PLATE XV.

Fig. 26. *Olenellus Callavei*, Lapw. Theoretical restoration, natural size.

II.—Petrological Notes on some Lake District Rocks.

By W. Maynard Hutchings, Esq.

During the last three years I have at various times collected and studied rocks from the Lake District. Some of them are, I think, of sufficient interest to render them worth describing. It is my opinion that a great deal of very interesting petrological work still remains to be done among these rocks, and that when they are more studied in detail they will be found to present more diversity of type than is usually supposed.

I will first note the occurrence of a variety of rock not previously recorded in this district. It is a quartz-andesite, or dacite. It is exposed on the ridge between Greenburn and Wytheburn, not very far from Dunmail Raise, and near to a new wire-fence which bounds, I believe, the property of the Manchester Waterworks. It is a dark-coloured rock, on a newly-fractured surface of which are seen numerous light spots of porphyritic felspars, and some of calcite, with many grains of quartz, some of good size. It was the grains of quartz which instantly attracted my attention to this rock when a bit was chipped off it in passing the exposed crag.

Under the microscope these grains of quartz are seen to be corroded and eaten out into "bays and gulfs," and their nature as true constituents of the rock, and not extraneous fragments, is vouched for by their enclosures of ground-mass. None of them show definite crystalline form. In addition to the larger porphyritic grains, some very small ones are seen among the ground-mass, but not abundantly.

The many porphyritic felspars are fairly well preserved. They are plagioclase, mostly well twinned, sometimes on both albite and pericline systems. So far as may be inferred from the extiction-angles of symmetrically-extinguishing twins, the chief felspar present appears to be oligoclase.

The porphyritic ferro-magnesian constituent appears to have been mainly, if not wholly, biotite, which was abundant. The outlines and cleavages of the numerous large individuals are still quite preserved, but great alteration has taken place into chlorite, epidote, and indeterminable matter, probably partly carbonates and ferric oxides.

I have not met with any other andesite in the district in which biotite can be recognized as present, or formerly present, nor am I aware of any such rock having been recorded. My impression is that biotite-andesite was very sparingly represented, though of course it is possible that the chlorite, so abundant in some cases, may partly represent former biotite; but in that case we should expect to sometimes see recognizable pseudomorphs, as one so frequently does in these rocks after augite.

The ground-mass of this quartz-andesite consists of a network of small felspar-laths, intermixed with, and at places more or less obscured by, grains of chlorite, epidote, sphene, calcite, and other matter, as is usual in all these rocks. In the greater portion of it the felspars are very distinct and fresh, and allow of optical measurements. They are largely untwinned, the rest being binary twins. Extinctions are either quite parallel or at very low angles. We may conclude that there is oligoclase, and most likely some orthoclase present. So far as can now be made out, very little, if any, glass was present in the original rock. There are many good-sized crystals of apatite, and zircons are much more numerous than in the usual local andesites. The sp. g. of the hand-specimen brought away is 2·74, and the silica-percentage is 60·45. Roth gives as the outside figures for silica recorded for dacites, 68·18 per cent., and 55·91 per cent. respectively, the latter being from an altered rock. It is not likely that the figure obtained by me for this Lake District dacite quite represents the *original* percentage, which, judging by the alterations, was probably a little higher, though certainly not nearly high enough to place the rock among the rhyolitic andesites. We have here, then, a well-characterized biotite-dacite, and it is likely that this or a similar rock will be found exposed at other points besides the one indicated.

Another rock occurring above Easedale Tarn, Grasmere, on the side towards Langdale, is a conspicuous representative of the other extreme of the series of Lake District rocks. It is a dolerite, a good deal more basic than any described by Mr. Ward, and differing in other ways from any hitherto recorded in the district. It is a very dark-coloured rock, easily recognized with a pocket-lens as a rather coarse-grained dolerite, without any porphyritic structure. Microscopic examination shows it to be made up of augite and plagioclase-felspar, with usual alteration-products. Augite is abundant, and much of it is still quite fresh. It existed originally, apparently, wholly as irregular grains, mostly of good size. The rock has undergone considerable crushing and shearing, and many augite-grains are cracked in several places, the cracks being cemented with chlorite. In some cases large grains have been completely shattered into small fragments, now lying among chlorite and calcite, due to subsequent infiltration. Here and there augite is fringed with secondary hornblende, but chlorite is the more usual alteration-product.

The felspar is in the form of relatively broad laths, tabular sections, and many irregular grains; it has been a good deal affected mechanically, like the augite, but is very fresh otherwise. There is no ophitic structure and no trace of ground-mass of any description. The rock is distinctly a holocrystalline, non-porphyritic dolerite, verging towards *granitoid* structure. The sp. g. is 2·95, and the percentage of silica is 45·65.

Another totally different type of basic rock examined is from near the summit of Scarf Gap Pass. Mr. Ward mentions a bed of basic lava on the east side of the pass, and gives description and figure of it. I do not know whether this is the same rock, and his figure is of very little use in deciding, while some points in his description do not agree with the occurrence here noticed.

It is a vesicular rock, the vesicles being now infilled with chlorite and other alteration-products. It has comparatively few porphyritic felspars, all very much altered. There is abundant porphyritic augite in good-sized crystals and grains, much of which is still perfectly fresh, though much fractured in some cases. The ground-mass consists of very small felspar-laths, perfectly fresh, nearly all binary twins. They are mainly if not wholly labradorite. There is the usual abundance of alteration-products throughout the ground-mass, but a good deal of augite in small grains is still distinguishable. There appears to have been a good deal of interstitial glass originally, but it is now devitrified, and obscured by alteration. The sp. g. is 2·82 and the silica-percentage 51·35. This rock, then, corresponds to a porphyritic augite-dolerite, or probably, more correctly, basalt.

Turning to the andesites, there is a type of them abundantly represented at one part of the district, and apparently recurring at several other points, which is very interesting and differs in several ways from the usual varieties as described by Mr. Ward, or as summarized by Sir A. Geikie (Presidential Address to Geol. Soc. 1891). It consists of rocks of mostly a grey-green or grey-blue colour,—a colour not easy to exactly describe,—with resinous lustre and extremely splintery fracture. On a newly-broken surface small dark spots are seen, but hardly ever any sign of a felspar, and when seen these are very small. These particular rocks are exposed largely at Harter Fell, Mardale, making the main part of the cliff facing towards Haweswater; on the ascent from Nan Bield Pass on to High Street; and in cliffs on the right side of Kentmere Valley, some distance below the reservoir.

A series of sections prepared from specimens taken at all three of the above localities shows that the rock is essentially the same in nature at all of them. There are numerous felspar-crystals, sharp in outline, though inwardly much altered, porphyritic in a ground-mass which originally varied from a wholly glassy base to an intimate mixture of glass and exceedingly minute felspar-microlites. There are chlorite-pseudomorphs after augite, distinct in form, as well as indefinite patches and streaks of chlorite. The entire ground-mass is permeated by chlorite in minute flakelets, with small granules of epidote, calcite, and other matter.

Sections from the summit of Harter Fell, close to the double cairn, show a good deal of perfectly fresh augite as well as many pseudomorphs. The ground-mass here consists nearly wholly of devitrified glass; a dimly-polarizing, speckly, felsitic mass with scarcely any felspar microlites at all. Sections from Kentmere, again, have a ground-mass of the most typical "hyalopilitic" nature, wherein the same devitrified glass is quite full of tiny laths and needles of felspar, showing well-developed flow-structure round the porphyritic felspar-crystals. The largest and most clearly-developed of these felspar-needles are close around $\frac{1}{1000}$th inch in length and extinguish quite parallel. The average size is very much less.

There is no doubt that, though varying more or less in detail from place to place, and even within very short distances, we have here an altered augite-andesite of a much more vitreous nature than the dominant type of lavas of the Lake District. A characteristic specimen from above Nan Bield has the sp. g. 2·65 and a silica-percentage of 57·55.[1]

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[1] Mr. Ward refers to rocks of a grey-blue colour, very compact, which are outwardly not unlike those above described. The closest resemblance is in a lava from near Lodore Hotel, which is singled out by him on account of its non-porphyritic nature and the smallness of its felspar-needles. He gives the average

Rocks closely similar to the above, macroscopically and microscopically, are exposed on both sides of Easedale Tarn, Grasmere. One specimen, from the right side of the Tarn, is very much altered and impregnated with calcite and other secondary matter, reducing its silica-percentage to 52·45. Its ground-mass appears to have been wholly vitreous, and porphyritic felspars, etc., are very scarce. Specimens from the opposite side of the Tarn are again full of minute felspar-needles, are less altered (free from calcite), and have a silica-percentage of 60·75; but here also the porphyritic constituents are much less abundant than at Harter Fell, etc.

From these vitreous and minutely "hyalopilitic" varieties, we may see all gradations of development of crystals in the ground-mass, up to the more usual, much coarser-grained andesites, as we mainly have them in Mr. Ward's descriptions.

An interesting example is exposed in a small disused quarry by the side of the road from Seatoller to Seathwaite. The rock is grey tinged with green, showing dark spots of chlorite, but no felspars to eye or lens. It is very fissile, splitting into tolerably thin plates, and approaches more nearly to a slaty cleavage than any other lava known to me in the district; though I am told there are cases of lavas which are sufficiently cleaved to be worked for roofing-slates. The ground-mass-felspars in sections from this quarry are still small, but larger than in the rocks just described, ranging up to $\frac{1}{300}$ of an inch as maximum. Porphyritic felspars are greatly altered, being almost wholly replaced by calcite, and deformed by pressure and shearing; but the pseudomorphs after augite are mostly but little damaged, and show more numerous recognizable forms than in any other slides I have. The ground-mass is completely permeated by infiltrated calcite, of which there is so much present altogether that the silica-percentage of the rock now only reaches 51·6, though originally it must have been fully as high as in the average local andesites, if not higher.

The numerous lavas on Dale Head, High Scawdell, and Seatoller Fell, present an interesting variety, as we find here not only the more normal Lake District andesites, but also types which seem to lie between these and the basic rocks, and to require such terms as doleritic (better basaltic) andesite, or andesitic dolerite (better basalt), to describe them;—that is, if we adhere to the more usual custom of distinguishing between andesites, and dolerites or basalts, as extremes of a series. Of course they all pass imperceptibly into one another, and there are petrologists who call the whole series andesites, as does Professor Cole in his system of classification ("Aids in Practical Geology"), simply distinguishing them at the ends of the line as "trachytic andesites" and "basaltic andesites." Rock-classification, in the present state of the subject, is very much

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length of these as $\frac{1}{176}$th of an inch. They are, therefore, very much larger than in the rocks referred to by me, and from his description the Lodore lava was evidently very much less vitreous than these. It resembles, as Mr. Teall points out, the ground-mass of the average andesites of the district; a ground-mass in which the felspars are above the average sizes of typical andesites elsewhere.

a matter of individual taste, so many are the systems offered to us. For my own part I think a very much clearer idea of the rocks is conveyed by the more usual method of separate grouping of andesites and basalts (using the name *dolerite* exclusively for non-vitreous rocks); as is exemplified in the classification given by Dr. Hatch ("Introduction to the Study of Petrology"). Various stages of the passage from one to the other extreme may then be clearly indicated by the use of the adjectives *basaltic* and *andesitic* respectively, according to whether we wish to specify an andesite which is tending towards a basalt, or a basalt which is tending towards an andesite.[1]

While on this subject, it is difficult to see why we should retain in use the word "porphyrite" for altered andesites like those of the Lake District. The supposed differences between rocks of different geological age being no longer admitted among English petrologists, and bound to vanish also in Germany sooner or later, why retain any of the names which are connected with the obsolete system of classification, and which appear wholly superfluous when once this is discarded? As some writer has said, I think, in effect, why should we have a separate name for an old and altered rock, any more than we have a separate name for a *man* because his hair is grey and his teeth no longer well preserved? Such names only burden the memory, obscure ideas, and open the way for confusion, because they are so liable to be used in different senses by different writers. It is better, and specially so for younger students, to use two words (or a whole sentence if necessary!), and to convey a clear and unmistakeable idea by their means, than to use one word which itself needs a definition attached to it, and very likely has several different ones. Why should not such words as porphyrite, melaphyre, propylite, and very many more, disappear into the lumber-heap? They are only a stumbling-block to beginners, and an unnecessary addition to a nomenclature too much burdened with dreadful names in any case.

The regular types of andesites of the district have in their ground-mass a felspar which shows very small angles of extinction, and sometimes extinguishes parallel.

It seems tolerably safe to assume that oligoclase largely prevails, and it is very probable that orthoclase is also frequently present. But there are also rocks in which these optical tests show a felspar allied to labradorite to be present in the ground-mass. Labradorite does not appear to be usually recorded as existing in the ground-mass of normally acid andesites. In some of the lavas on Dale Head, etc., examples of it may be seen, lavas which are very full of porphyritic felspars and are unquestionably *andesites*.

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[1] Mr. Teall uses the term "andesitic dolerite" on several occasions, pointing out that some authors would simply call such rocks augite-andesites; and he adds the very sensible reminder that "it is a matter of indifference what we call them, provided we recognize their true characters and relations" (British Petrography, pp. 194, 195).

A rock from Seatoller Fell is of some interest. It is a very compact, dark rock, quite free from vesicles. Its numerous porphyritic felspars are all much altered, though still perfect in outline and relationship to the ground-mass. There are no definitely recognizable larger pseudomorphs of chlorite after augite, though good large patches of chlorite are present. The ground-mass consists of perfectly fresh felspar-laths of a rather larger size than usual, all twinned, and showing by many extinction measurements that labradorite is dominant. These felspars lie in among a yellow-brown, dimly-polarizing, partially devitrified glassy base, full of minute dark dusty matter. The amount of this base is considerable. In among the felspars and glass are a large number of good-sized irregular grains of very pale-green hornblende, which is clearly secondary after former augite. In many cases the felspars penetrate the hornblende in a manner showing that a certain amount of ophitic structure was present, but more usually the grains lie wedged in the angles formed by the felspars. There are also numerous bits of chlorite occurring in exactly the same manner as the hornblende. Originally the rock must have contained a considerable amount of augite in this form, but none of it is now seen unaltered. There is abundance of finely disseminated chlorite and grains of epidote, some of which appears to represent a smaller generation of augite in the ground-mass. The sp. g. is 2·88, and the silica-percentage 53·55. This rock would have to be classed as "andesitic basalt."

Hornblende secondary after augite is not at all frequently observed in these rocks. There is another lava on Seatoller Fell, a normal andesite, in which it occurs as prismatic grains of deep green colour, this being the only case in which I have observed hornblende in one of the regular local andesites. Original hornblende is never seen nor any sign that it ever was present. It seems probable that hornblende-andesites were never represented in the district.

Enstatite has been shown by Prof. Bonney (Geol. Mag. 1885, p. 77) to have been a constituent of some of the Eycott Hill lavas; and Mr. Teall supposes it probable that the andesites of the district contained it. I have sought carefully for it in many rocks from various localities, but have not found it, nor any secondary product which suggests it, in any undoubted lava. In a rock from Dale Head, of which I am uncertain whether it was a flow or an ash, there are good-sized serpentine-pseudomorphs after some mineral, which I think was very probably enstatite. The secondary mineral is not bastite. Again, in an ash or tuff from the summit of Sargeant Man a good deal of serpentine appears, some of it in the form of small prismatic pseudomorphs, contained in andesitic lapilli, strongly suggestive of original crystals of enstatite; and in a tuff from Glaramara one good-sized serpentine-pseudomorph is also seen, the form being quite that of the enstatites of andesites, etc.

It would seem likely that enstatite was a rare constituent of these rocks.

A rock occurs at Thornthwaite Crag, a little below the tall Cairn, which differs sufficiently from the usual andesites to be worthy of mention. It is a grey-green, highly vesicular rock, the vesicles now filled with chlorite and chalcedony. In thin sections the difference alluded to is apparent in the felspars of the ground-mass. These to a very large extent consist of untwinned laths, many very elongated in proportion to breadth, and extinguish mainly quite parallel to their length. Such of them as are twinned are almost without exception binary twins, and of these a large proportion extinguish simultaneously and again quite parallel, or at very low angles. There are a good many square tabular sections also seen, more than in any other local andesites examined. The laths are of various sizes, and pass down to very small ones with mainly forked and ragged ends. So far as optic discrimination in thin sections is a guide, the felspar in this ground-mass seems to be mainly, if not almost wholly, orthoclase. There is a good deal of devitrified interstitial glass and the usual amount of diffused alteration-products. The porphyritic felspars are still fairly fresh, and several of them in some of the slides examined appear to be orthoclase, while in others they are wholly plagioclase, the ground-mass remaining as above described. In one hand-specimen there are large groups of felspar crystals clustered together in the manner described by Mr. Teall in the case of the Tynemouth Dyke; that is, they are *idiomorphic* towards the outside of the group, and *allotriomorphic* inside it. Some of these groups are so large that they give the effect, on fractured surfaces of the rock, of being infillings of good large vesicles with felspar, but the microscope shows their true nature.

Some of this rock was prepared for analysis by crushing moderately small and picking out sufficient bits quite free from vesicles or their contents. The analysis was kindly made for me by Dr. J. B. Cohen, of Owens College, and is calculated on dehydrated rock:—

Silica	= 58·69	per cent.	
Alumina	= 15·84	„	
Ferric Oxide ...	= 8·62	„	(Ferrous Oxide not determined.)
Lime	= 3·43	„	
Magnesia	= 2·91	„	
Manganous Oxide	= 0·58	„	
Potash	= 3·86	„	
Soda	= 5·06	„	
	98·99		

These figures would stand equally well for a trachyte or an andesite, the proportions of the alkalies being much the same as in many analyses given of trachytes; agreeing for instance almost completely with one of the "typical analyses" given by Professor Cole in his "Aids in Practical Geology." It appears that whether a magma of certain composition will consolidate as trachyte or as andesite, depends largely on conditions other than purely chemical. The rock in question is not a trachyte, but it would become one by a very moderate degree of further differentiation from the accompanying andesites. Rocks with a closely similar orthoclase ground-mass, and some apparently orthoclase porphyritic crystals, occur also near Keswick.

It is not at all unlikely that undoubted trachytes may be found in the Lake District. Sir A. Geikie, in his address above referred to, alludes to the general resemblance of these lavas to the "porphyrites" of the Old Red Sandstone in Scotland, and Dr. Hatch quotes the authority of Professor Judd for the fact that "excellent sanidine-trachytes" exist among these rocks at Haddington ("Introduction to the Study of Petrology," p. 100). Some lapilli seen in certain tuffs also suggest that good trachytes exist somewhere among the Lake rocks.[1]

Sir A. Geikie states that from the observations of himself and Dr. Hatch on the rocks of the Lake District, he concludes that lavas are much more abundant among them, relatively to "ashes," than was allowed by Mr. Ward in his Survey Memoir and other writings. In this conclusion it is probable that most workers in the district would now agree. But there are, of course, many cases in which it does not seem possible to decide whether they are flows or ashes, either in the field or with the microscope,—certainly not with the latter. The difficulties of this kind of examination are very fully (not to say a little gloomily!) put forth in a paper by Mr. Rutley ("On Community of Structure in Rocks of Dissimilar Origin," Q.J.G.S. vol. xxxv. 1879), and anybody who may be in danger of underrating these difficulties, or of getting too much confidence in his power to solve them, or indeed to solve any sort of questions whatever in microscopic petrology, would do well to read that paper.

The chemical and mineralogical changes which have taken place in these rocks are of very great interest in some cases. They are, however, most fully seen in the detrital rocks,—the ashes and tuffs,—and I hope to return to some of them in connexion with a study of the ash-slates, etc., of the district.

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[1] Prof. Cole points out ("Aids in Practical Geology") that the older trachytes (or quartzless porphyries, orthophyres, etc.) may often be difficult to mark off from the rhyolites, and suggests that the marked absence of porphyrite quartz in some of the "altered rhyolites" may give rise to a suspicion that they were trachytes. There is a "rhyolite" exposed in the plantation in front of Shap Wells Hotel, which differs notably from the other rhyolites near to it. Macroscopically it shows crystals of felspar more prominently than any of the others do. Microscopically it shows an abundance of felspar-laths and microlites, all orthoclase, lying in a rather plentiful cryptocrystalline base, "speckly" in polarized light, apparently devitrified glass. Such laths and microlites are absent from the other local rhyolites. There is none of the spherulitic structure so abundantly developed in these rhyolites, and there is no sign of free quartz or of "granophyre." The silica-percentage of a specimen collected by me is 61·15, as contrasted with over 75 per cent. found in rhyolites of Wasdale Head and Stockdale by Mr. Garwood. The microscope shows nothing whatever to lead to the supposition that the silica-percentage has been lowered by decomposition or infiltration, the rock being very free from chlorite, etc. This was apparently never a rhyolite, but was most probably a trachyte with a large amount of glassy base.

III.—*PHOLIDOPHORUS GERMANICUS*: AN ADDITION TO THE FISH FAUNA OF THE UPPER LIAS OF WHITBY.

By A. SMITH WOODWARD, F.G.S., F.Z.S.

SEVERAL species of Vertebrata are now known to be common to the Upper Lias of the neighbourhood of Whitby, Yorkshire, and the corresponding formation so widely developed in parts of Würtemberg and Bavaria. The recent discovery of another link between the two faunas in question thus seems to be worthy of placing on record. Moreover, the latest comparisons render it possible to assign to the fossil under consideration a more precise specific diagnosis than has hitherto been published; and the announcement of the discovery may lead to the recognition of other specimens besides those in the British Museum, with which alone as yet the present writer is acquainted.

The fossil in question is a Lepidosteoid fish, long ago observed by Quenstedt in the Lias of Würtemberg, and briefly described under the name of *Pholidophorus germanicus*.[1] A figure of the head and anterior portion of the trunk accompanies the original description; and it is satisfactorily proved that the fish is a typical species of the well-known early Mesozoic genus to which it is referred. It is the largest known Liassic species of *Pholidophorus*, attaining a length of nearly 0·3 m.

Two almost complete examples of the species, and four more fragmentary specimens were obtained from the neighbourhood of Whitby by the late Sir Philip Egerton and the Earl of Enniskillen. These at present form the series in the British Museum. They agree precisely in all their characters with several typical specimens of *Pholidophorus germanicus* from Ohmden, Würtemberg, in the same collection; and the chief points of specific importance are noted in the following paragraph.

As usual in *Pholidophorus*, the body is gracefully fusiform in shape. The length of the head with the opercular apparatus somewhat exceeds the maximum depth of the trunk, which equals about one-fifth of the total length of the fish. The rugose ornament of the head and opercular bones—especially that of the cranial roof—is very fine and conspicuous; and the rugæ on the maxilla and dentary bone tend towards a longitudinal striation. The pelvic fins arise slightly in advance of the middle point of the trunk, and are provided with small fulcra (as especially well shown by B. M. No. P. 1058). The dorsal and anal fins are of the ordinary small proportions, and the former is directly opposed to the pelvic pair. The scales are large and nearly smooth, but with a faint, coarse rugosity, most conspicuous in the caudal region; their hinder margin is very slightly convex, and not serrated; and there are at least six longitudinal series of flank-scales much deeper than broad.

Of the characters just mentioned, the peculiar ornament of the scales seems to be especially distinctive, and renders possible the determination even of fragments. The feebly marked rugæ are broad and rounded, and towards the superior margin of the scales, more particularly on the caudal pedicle, they exhibit a tendency towards arrangement in a series of short, parallel, vertical folds.

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[1] F. A. Quenstedt, "Der Jura" (1858), p. 234, pl. xxx. figs. 9–11.

IV.—*PSEUDOTRIONYX* FROM THE BRACKLESHAM BEDS.

By A. SMITH WOODWARD, F.G.S., F.Z.S.

THE extinct genus of Chelydroid Chelonians to which M. Louis Dollo gave the name of *Pseudotrionyx*,[1] has already been recorded from the London Clay of Sheppey, by Messrs. Lydekker and Boulenger.[2] It is somewhat remarkable, however, that until the recent acquisition by the British Museum of the collection of Mr. J. B. Ogle, no certain evidence had been observed of the occurrence of the genus in the Bracklesham Beds—the English equivalent of the Bruxellian Series which yielded the Belgian *Pseudotrionyx Delheidi*.

This evidence is still very small, but appears nevertheless conclusive. It consists of one of the middle marginal bones, well preserved and showing the pit for the reception of the extremity of the rib. The bone measures 0·05 m. in length, 0·042 in the maximum width of the upper face, 0·03 in that of the lower face, and 0·018 in the maximum thickness of the angulation. Both the upper and lower faces of the bone are covered with the characteristic coarse, but faintly-marked pitted ornament; and the angulation of one extremity measures about 90°, while that of the other is slightly greater.

The fossil thus described agrees so closely in its proportions and sculpturing with the type-species *P. Delheidi* that, in the absence of further material, it may be assigned to this form.

V.—NOTES ON *STEREODON MELITENSIS*, OWEN.

By JOHN H. COOKE, F.G.S., etc.

IN the year 1865 portions of the upper and lower jaws of a large extinct fish that had been found imbedded in the Globigerina Limestone[3] of Malta were submitted by Dr. Leith Adams to Professor Owen for identification. Adams had considered them as being the remains of a crocodilian; but in a paper that appeared in the GEOLOGICAL MAGAZINE for April, 1865,[4] Owen pronounced them to be the remains of a large extinct fish that belonged to "the cycloid order, and having sauroid dentition," and he proposed that "this fine addition to Miocene Tertiary fishes" should be known by the name of *Stereodon Melitensis*.

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[1] L. Dollo, "Première Note sur les Chéloniens du Bruxellien (Eocène Moyen) de la Belgique," Bull. Mus. Roy. d'Hist. Nat. Belg. vol. iv. (1886), pp. 75–96, pls. i. ii

[2] R. Lydekker and G. A. Boulenger, GEOL. MAG. [3] Vol. IV. (1887) p. 274.

[3] Bed IV. The "freestone" of Spratt and Adams.

[4] "Stereodon Melitensis," Owen, GEOL. MAG. April, 1865.

A portion of the bony skeleton of a fish of the same species was also discovered in the same locality; but as it was not sent with the other specimens, it has been neither figured nor described.

In the course of his paper Owen repeatedly refers to it, and finally concludes by saying, "It is much to be desired that the rest of the skeleton of this extinct fish should be figured." No attempt has, hitherto, been made to carry out this suggestion, and as no record of this interesting specimen exists, I have therefore visited the Malta Museum, wherein the fossil is now deposited, and have obtained the following particulars relating to it.

The specimen is oblong in shape, and measures $22\frac{3}{8}$ inches from the snout to the 10th dorsal vertebra. It consists of a fragment of the head, and a portion of the vertebral column, the latter of which extends as far as the 10th dorsal.

The vertebræ are circular in shape, and they form a continuous chain which curves slightly in a downward direction. They are well ossified, but, unfortunately, most of them have been badly developed from the matrix, and their characteristic features have thereby been obliterated. The 1st, 2nd, 3rd, and 5th are, however, in an excellent state of preservation; and the 10th vertebra distinctly shows deep lateral pits longitudinally extended. Each vertebra is bi-concave, and its body is somewhat depressed towards the middle. Compared with the posterior diameter, the antero-posterior diameter is much the shorter of the two.

Posterior diameter of the 6th dorsal vertebra ...	$1\frac{1}{8}$ inches.
Antero-posterior of the 6th dorsal vertebra ...	$\frac{3}{4}$ of an inch.
Posterior diameter of the 10th dorsal vertebra ...	$\frac{6}{8}$,,
Antero-posterior of the 10th dorsal vertebra ...	$\frac{3}{4}$,,

The average diameter of the posterior extremities is $1\frac{3}{8}$ inches.

Above and below each of the vertebræ exhibits a broad protuberance, which forms the base of a long, sword-shaped spine, the flattened sides of which lie in a plane with the vertebral column, while the thin edges lie in the direction of the articular facets. These spines are anchylosed with the neural and hæmal arches of the vertebræ. They average three inches in length, and half an inch in width. The neural spines spring obliquely upwards and backwards from the centrum, while those on the hæmal side spring obliquely downwards and backwards, and gradually become shorter and more slender as the caudal extremity is approached.

There are no traces of scales.

Considerable portions of the bones of the head have been preserved in the limestone matrix, but most of them are so crushed as to be quite unrecognizable.

A fragment of the left branch of the lower jaw, containing a tooth which is similar in every respect to those that formed the subject of Professor Owen's paper, is intact, and thus affords an opportunity for the comparison of the two fossils.

HIGHLAND HOUSE, ST. JULIAN'S, MALTA.

NOTICES OF MEMOIRS.

I.—Geological Survey Publications.

1. The Geology of the Country around Mallerstang, with parts of Wensleydale, Swaledale, and Arkendale. By J. R. Dakyns, R. H. Tiddeman, R. Russell, C. T. Clough, and A. Strahan. (Parts by J. G. Goodchild, C. E. De Rance, G. Barrow, and F. H. Hatch.) 1891. pp. 213. Price 3*s.* 6*d.*

THE area described by the numerous authors in this Memoir is, for the most part, an elevated tract rising 2000 feet and more above the sea-level, and including the sources of the rivers Ure (or Yore), Swale, Lune, and Eden. The oldest rocks exposed belong to the Coniston Limestone Series, and of this series the Ashgill shales form the upper part, and the top of the Lower Silurian (or Ordovician). The lowest division in the overlying Upper Silurian system is that known as the Stockdale shales, and it is remarked that its base is determined principally on palæontological considerations, for there is an abrupt change from the fauna of the beds below, without any stratigraphical unconformity. Succeeding the Stockdale Shales are the Coniston Flags and Grits, and the Bannisdale Slates. Resting unconformably on the Silurian rocks comes the great Carboniferous series, including representatives of the Basement red conglomerate and sandstone (which may be of the age of the Upper Old Red Sandstone), Lower Limestone Shales, Great Scar Limestone Series, Yoredale Rocks, and Millstone Grit. The description of these rocks occupies the greater part of the Memoir, which indeed deals with the district of Uredale (Yoredale) or Wensleydale, from which the Yoredale rocks take their name. Some Permian and Triassic rocks, as well as Glacial Drifts and Recent deposits, are described. There are also notes on the Lead-mining, on the Coal-beds which occur in the Yoredale Series and Millstone Grit, and on the Building-stones.

Dr. Hatch contributes notes on the Eruptive rocks; and there is a list of Carboniferous fossils by Mr. Etheridge.

2 The Geology of Parts of Cambridgeshire and of Suffolk (Ely, Mildenhall, Thetford). By W. Whitaker, H. B. Woodward, F. J. Bennett, S. B. J. Skertchly, and A. J. Jukes-Browne. 8vo. pp. 127. Price 2*s.*

IN this Memoir we have the accounts of the Oxford Clay, Corallian Beds, and Kimeridge Clay of the neighbourhood of Willingham, Upware, and Ely. Mr. T. Roberts has contributed a revised list of the Upware Fossils (from his, as yet unpublished, Sedgwick Essay of 1885); and Mr. E. T. Newton has some notes on the Vertebrata from the Kimeridge Clay, in the collection of Mr. Marshall Fisher of Ely. Then follow notes on the Lower Greensand and its Coprolite Beds, on the Gault, and on the several divisions of the Chalk which includes the Coprolite Bed of the "Cambridge Greensand."

About half the work is devoted to Glacial and Post-Glacial Drifts, and this includes notes by Mr. Skertchly on beds at Culford, Mildenhall, and other places, where he obtained worked flints, believed by him to have come from strata older than the Chalky Boulder Clay; as Mr. Whitaker remarks, the question is whether the implements were really obtained from the beds in which they were reported to have been found.

A number of records of well-sections are given, and there are supplementary geological bibliographies of Cambridgeshire and Suffolk.

3. EXPLANATIONS OF HORIZONTAL SECTIONS.

Nos. 130 to 139 have been prepared by Mr. C. FOX-STRANGWAYS, with the assistance of Mr. H. H. HOWELL, Mr. CLEMENT REID, and Mr. GEORGE BARROW. They give concise descriptions of the Jurassic, Cretaceous and other strata in various parts of East Yorkshire. Explanation of Horizontal Section, Sheet 140, by Mr. Horace B. Woodward, describes the Jurassic and other strata along a line from Bishopstone, near Hartwell, to near "the Centre of England" at Wibtoft in Warwickshire. These explanations are issued to the public at the modest price of 2*d.* each.

II.—CARBONIFEROUS CEPHALOPODS. By ALPHEUS HYATT. From Second Annual Report of the Geological Survey of Texas, 1890. pp. 329–356. (Austin, State Printing Office, 1891.)

THE descriptions given in this paper were taken partly from a collection forwarded to the author by Mr. E. T. Dumble, State Geologist of Texas, partly from specimens belonging to the United States National Museum, Washington, D.C., and partly from specimens belonging to private individuals whose names are given in connexion with the specific descriptions. As stated in an introductory note, the forms here described comprise a larger number of Carboniferous species than has hitherto been got together in a single publication. The genera represented are divided between the *Nautiloidea* and the *Goniatitinæ.* To the former belong *Temnocheilus* with five species (*Forbesianus, latus, conchiferus, depressus,* and *crassus,* the last three being new); *Metacoceras* with five new species (*cavatiformis, dubium, Walcotti, Hayi* and *inconspicuum*); *Tainoceras* with one new species (*cavatum*); *Domatoceras,* a new genus allied to *Centroceras,* represented by the new species *umbilicatum*; *Asymptoceras* with one new species (*Newtoni*); *Phacoceras* with one new species (*Dumbli*); *Ephippioceras* with one new species (*divisum*); and *Endolobus* with one new species (*gibbosus*). The *Goniatitinæ* are represented by the genus *Gastrioceras* with the new species *G. compressum.* The descriptions are accompanied by outline figures.

III.—PROCEEDINGS OF THE COTTESWOLD NATURALISTS' FIELD CLUB FOR 1890–91, Vol. X. Part 2, 1891.

THREE of the four papers in this Number of the Proceedings are devoted to Geology; even the address of the President, Mr. W. C. Lucy, is largely concerned with the same science, giving as it does accounts of excursions to Lydbrook and Symond's Yat, May Hill, Eastnor, Swindon, and Avebury.

The first paper is by Mr. H. D. Hoskold, and entitled "Geological Notice upon the Forest of Dean." In it the author gives a very full account of the formations, referring to the early work of Buckland and Conybeare, David Mushet, De la Beche, and others, and adding a number of new records of the strata passed through at various collieries. He estimates that the Forest of Dean contains nearly 250 millions of tons of coal available for use—the amount raised during 1888 was a little over 800,000 tons.

Professor Allen Harker contributes a paper "On the Geology of Cirencester Town, and a recent discovery of the Oxford Clay in a deep well-boring at the Water Works." He gives accounts of various wells in the neighbourhood, and announces the discovery of a small faulted tract of Oxford Clay that was proved by a boring at Lewis Lane, Cirencester. Important details of the Forest Marble and Great Oolite are given.

Dr. Frederick Smithe and Mr. W. C. Lucy furnish "Some Remarks on the Geology of Alderton, Gretton, and Ashton-under-Hill." Their descriptions refer to the Middle and Upper Lias, and they give lists of fossils from these formations at Alderton Hill. Among the records are *Ammonites radians* from the Upper Lias (lower part), and *A. aalensis* from the Middle Lias; identifications which we anticipate will be doubted by those who believe in the rigidity of zones.

REVIEWS.

I.—SYSTEMATIC LIST OF THE FREDERICK E. EDWARDS COLLECTION OF BRITISH OLIGOCENE AND EOCENE MOLLUSCA IN THE BRITISH MUSEUM (Natural History), with references to the type-specimens from similar horizons contained in other collections belonging to the Geological Department of the Museum. by RICHARD BULLEN NEWTON, F.G.S. [With Appendix by G. F. HARRIS.] London, printed by order of the Trustees and sold by Longmans & Co.; B. Quaritch; Dulau & Co.; and Kegan Paul, Trench, Trübner & Co., Paternoster House, Charing Cross Road, W.C. 8vo. pp. xxviii. and 365, 1891.

THIRTY-SEVEN years have elapsed since the historic "Catalogue of British Fossils," by Professor John Morris, saw its second edition published; a modest work of 372 pages, 8vo., embracing all classes of fossil-remains.

Since that date, a long array of British Fossils have been figured and described, many groups of the Invertebrata being fully Monographed, as for example, the Brachiopoda, by Dr. Davidson; the Sponges, by Dr. Hinde; the Blastoidea, by R. Etheridge and P. H. Carpenter; the Merostomata, by Dr. Woodward. In others great progress has been made as in the Foraminifera by Carpenter, Parker, Jones, and Brady; the Hydroida by Nicholson; the Polyzoa, by Busk and Vine; the Trilobites by Salter and Woodward; the Entomostraca and Phyllopoda, by Prof. Rupert Jones; the Corals, by Prof. Duncan; the Echinoidea, by Wright; the Decapod Crustacea, by Bell and Woodward; the Cephalopoda, by A. H. Foord; and the Tertiary Mollusca, by F. E. Edwards and Searles V. Wood.

In CATALOGUES, serving as supplements to Morris, we have (1), a complete "Catalogue of British Fossil Vertebrata," by Arthur Smith Woodward and C. Davies Sherborn, 1890, 8vo. pp. xxxv. and 396; larger by 51 pages than the space occupied by Morris for the whole of the classes of Plantæ and Vertebrata in 1854. (2), Fossils of the British Islands Stratigraphically and Zoologically Arranged, Vol. I. PALÆOZOIC, by R. Etheridge, F.R.S., 4to. 1888, pp. 475, giving 6022 species from the Cambrian to the Permian.

Mr. Etheridge tells us that Vol. II. Mesozoic, and Vol. III. Cainozoic, are *still in MS.*, and, adding their contents to the Palæozoic volume already published, we have 18,000 species of British Fossils, both Fauna and Flora, up to 1888.

Morris's Catalogue, up to 1854, records a total of 8359 species; so that, according to Etheridge, there had been an increase of at least 10,000 species in thirty-four years from 1854 to 1888.

The only other catalogues which supplement Morris's Catalogue are British Fossil Crustacea, by H. Woodward, F.R.S. (1877); Fossil Foraminifera, by Prof. T. Rupert Jones, F.R.S. (1882); Palæozoic Plants, by Robert Kidston, F.G.S. (1886); and lastly that of the Edwards Eocene Mollusca, by Mr. R. B. Newton, now before us (dated 25 July, 1891).

This important work gives us a carefully prepared record of 1229 described species of British Eocene and Oligocene Mollusca, distributed in 255 genera; 428 being Lamellibranchiata, 786 Gasteropoda, and 15 Cephalopoda.

In addition to the whole of the Edwards Collection, this volume also contains a record of all the "types" of Eocene Mollusca contained in the Bowerbank, Brander, Brown, Dixon, Gardner, Mantell, Prestwich, Shrubsole, William Smith, Sowerby, Wetherell, and Wise Collections, all preserved in the British Museum of Natural History. Every species bears after it its author's name, the date when given, and references to the principal works where it has been figured and described, with its synonyms, and lastly the horizon and locality in which it occurs.

570 MS. names of species, proposed by F. E. Edwards, are also given; but as these have never been described, they cannot be considered as of value, save as indicating that Mr. Edwards believed they marked new and undescribed species. Many of these names have been printed in various lists previous to the publication of Mr. Newton's Catalogue; and the author states (in

his Introduction, page v) his intention to describe and figure all those specimens bearing MS. names in due course; we hope he will keep his resolution strong, and get them all as speedily as possible stamped with the imprimatur of authority.

Apart from this, the work is a step in the right direction. which all who are interested in Malacology will be delighted to welcome. For many years past the nomenclature adopted for the fossil Mollusca in England has been much behind the times, many quite dissimilar forms being frequently included in the same genus. In the work before us, as the result of recent researches, many of these old genera have been split up into two or more genera, and although the older workers may denounce this as fiercely as in Joshua's days they cursed the man who removed his neighbour's landmark, nevertheless, in a more calm and philosophical state of mind, we are compelled to admit that these adjustments, if honestly and judiciously made, must be of material assistance to the student in the future, especially if he is attempting to correlate (as he ought) the recent with the fossil forms.

This revision has not been carried out always with equal rigour by the author. The old genus *Cerithium*, for example, has been very properly split up into several genera; but *Pleurotoma*, which also needed revision, is retained in full force, although numerous Malacologists have shown that it comprises many genera well known to the student of living mollusca.

Again, the genus *Chrysodomus*, in the work before us, includes a number of diverse forms which might have been dealt with more analytically by the author.

In a first attempt at completing such a task as was left behind unfinished by F. E. Edwards and Searles V. Wood, it must necessarily follow that much more is needed before the work can be said to be thoroughly accomplished.

In carefully following the original authors in their varied spelling of species, and terminations of the names, Mr. Newton has laid himself open to criticism from the more exact writers on recent and fossil shells, who would, in their earnest desire for uniformity, alter the terminations of such names so as to bring them all into one regular line, like a regiment under inspection; but, unless absolutely a misspelling, many writers consider such alterations of names actually wrong.

Thus Deshayes' name is used specifically in eight different genera, and by as many different authors, four species being spelt *Deshayesii*, and four *Deshayesi*. Similarly. we have *Bowerbankii* on page 22, and *Bowerbanki* on page 219; *Wetherellii* on page 26, and *Wetherelli* on page 215. In each case the names are by different authors, and given according to their own notions.

Some few specific names vary to the extent of two final letters. Thus we have *Cardium Etheridgii*, p. 51, and *Helix Etheridgei*, p. 270; *Aporrhais Sowerbii* (p. 97) *Bullinella Sowerbyi* (p. 266), and *Planorbis Sowerbyi* (p. 283); but different authors have each adopted their own termination, and these Mr. Newton has retained and respected.

In the matter of generic names, and the changes which they have undergone, it would be no exaggeration to say that numbers of these genera have now as many aliases as a notorious pickpocket or a crack burglar.

If opinion as to the lines upon which alterations of names should be made was only unanimous, much labour would be spared. Some Naturalists hold that a name used for a genus of Vertebrates, as *Palæoniscus*, Blainville, 1818, for a genus of fossil fishes; and *Palæoniscus*, Milne-Edw., 1843, for a genus of fossil Isopods, need never disturb our peace of mind or our nomenclature; but it seems to be considered desirable that such repetitions should as far as possible be eradicated from the *Index Zoologicus*.

Names, once familiar as household words, are now constantly being swept away, and all our ancient landmarks cast down. But we are told it is for our good, and, like the "nasty doctor's stuff," we are bound to swallow it. We would like, however, to see these changes effected with more reverent and careful hands, and without that indecent haste which too often marks the action, as if the alteration of a name were a noble achievement in science, whereas it too often simulates, but in a more humble sphere, those barbarian conquerors of Egypt or of Nineveh, who erased every preceding monarch's name on temple and on palace and substituted their own. There is something more in science than a name, and those who would earn the gratitude of posterity may do so by adding to the walls of her ever-rising temple some well-worked stones: let whoever will, afterwards, cut or scratch his name thereon, he will at least have the nobler satisfaction of having done a piece of *solid work.*

The Introduction deals with the alterations in nomenclature made by the author; there is a good Bibliography (pp. 299–325), followed by a very useful Appendix prepared by Mr. George F. Harris, F.G.S., "On the Correlation of British with Continental Tertiary Strata," illustrated by a series of small tables and a large folding-table, which gives the equivalents for each horizon, as far as possible, for English and Foreign localities where Tertiary fossils have been obtained. This cannot fail to prove most useful to all students and workers in these deposits and is an excellent piece of work.

We congratulate Mr. Newton on the completion of his Catalogue, and hope he will follow it up with figures and descriptions of the new or little known species of Eocene shells in the Edwards Collection in the British Museum.

II.—The Eocene and Oligocene Beds of the Paris Basin. By George F. Harris, F.G.S., and Henry W. Burrows, A.R.I.B.A. (A Paper read before the Geologists' Association April 3, 1891). Published by Edward Stanford (Price 3*s*.). 8vo. pp. viii. and 130. September 23rd, 1891. Illustrated by a Geological Map and numerous Sections.

THE Geologists' Association can no longer be spoken of as a *young* Society, and hardly deserves the title of a Society of *Amateur* Geologists. It was established in 1859, and is consequently in its thirty-third year, and numbers amongst its 550 members a large proportion of the most eminent and accomplished geologists and palæontologists in England. Its Proceedings have become the depository of a most valuable series of Memoirs; the records and illustrations of its excursions, which extend to Belgium, France, and Italy, form a volume by themselves; and having, if we may assume, exhausted the geology and palæontology of their own country, they are attacking and peacefully re-conquering the ancient country of France, by publishing, in a separate form, a Memoir on the Eocene and Oligocene Beds of the Paris Basin. The authors of this work have qualified themselves for the task by repeated careful examinations of the French Tertiary area, and one of them by an extended traverse over other parts of the Tertiary formations of Europe. They justify the special study of the French Tertiaries on the ground "that no adequate conception can be formed as to the meaning and value of our own Tertiary beds and their organic remains without conjointly studying those on the other side of the Channel—especially in regard to the palæontological aspect of the subject." They point out that the Mollusca have always afforded the best basis for correlating the several horizons in France, Belgium, and England, by reason of their abundance, their wide distribution, and the very perfect state of preservation in which they occur, especially in the Paris basin; so that the French area supplies, as it were, the key by which to open up and interpret correctly the sequence and life-history of other Eocene and Oligocene strata in neighbouring areas.

The authors deal especially with the Mollusca, and in order to equip themselves thoroughly for the task, they have worked very carefully and critically over the great French collection acquired from G. P. Deshayes some forty years since, and preserved in the Geological Department of the British Museum (Natural History). These specimens bear, in almost every case, Deshayes' original labels, and therefore form a valuable basis for fixing their nomenclature even where, as in so very many instances, these names have now to be exchanged for more modern and presumably more correct determinations. They have also visited and examined the chief collections in Continental Museums.

Pages 1–44 of this Memoir are occupied with a carefully prepared description of the Eocene and Oligocene Beds of the Paris Basin, well illustrated with sections at Issy; at Cuise-la-Motte; at Arcueil; at Auvers; near Ver, on the road to Ermenonville; at La Chapelle-en-Serval; at Butte d'Orgement; and Quarry of Vintué, near Étrechy. In each, the lithological characters of the several beds are clearly given, as well as the typical Mollusca which mark each horizon. This is followed (pp. 44–56) by an Outline Guide to the principal sections and fossiliferous localities. Here is useful practical advice to collectors (p. 45). "A word or two as to the collection of fossil may be useful. Strong calico bags of various sizes, but mostly large, say 12 in. by 7 in. to 7 in. by 4 in. are the best receptacles for fossils, and they should be so made that the mouth can be drawn together and tied by tape. A brass ring sewn on enables several bags to be threaded on a strap and carried with ease, without fear of breaking."

"Sift! is the watchward in the Paris area, as the smaller species of mollusca are always missed if this be neglected. Two wire sieves, one sixteen meshes and the other eight meshes to the linear inch, are suitable. A hammer is not often required; a pointed trowel, with a blade 5 in. or 6 in. long, is exceedingly useful for taking up the loose material. Some chip boxes, to hold the rarer or more delicate species, should be provided. A written label, tied to the ring of each bag, shows at a glance the locality and formation of the contents. For the fossils of the *Sables Inférieurs*, some preservative, such as potassic silicate, is required; or they may be brought away wrapped in cotton-wool, and subsequently treated. But by far the greater number of the fossils are in a magnificent state of preservation, and are easily collected and carried without the least risk of fracturing them." Thus equipped, and with Messrs. Harris and Burrows for travelling companions, we visit more than eighty localities, and have a really good time. Those who cannot arrange to be "personally-conducted" by the authors, must spend "three shillings nett," and have the benefit of their *printed directions*, without which it will be next to impossible to make a successful tour to the many widely-separated rural French districts. And here the excellent Map, which accompanies this book, proves most useful.

The last section (pp. 57–129) is occupied with a description of the Palæontology of the Eocene and Oligocene Beds of the Paris Basin.

The authors have received the assistance of Mr. Arthur Smith Woodward with the Vertebrata (a careful list of which is given, including Mammalia, 19 species; Aves, 12; Reptilia, 10 species; Pisces, 33 species). The Arthropoda are credited with 5 genera; the Echinoidea with 14 species; the Brachiopoda with 20 species; the Bryozoa with 4 species; the Actinozoa with 11 species; the Foraminifera are too numerous to catalogue. The Plantæ are briefly referred to. References are given to authors for the several groups; so that the student may go to the original works in every case.

The Mollusca occupy from pp. 63–124. Tables are given of all the species, arranged with columns showing the range of each from the Lowest Eocene; the Lower Eocene; the Middle and Upper Eocene. The Oligocene Mollusca form a separate table. These Tables of Genera and Species, which occupy 48 pages of the work, produce the following summary.

For the Eocene Beds of the Paris Basin:—

Pelecypoda or Lamellibranchiata (including additional species on page 114 supplied by Cossmann)	1083	
Oligocene Lamellibranchiata	112	
		1195
Eocene Gasteropoda (including additional species supplied by Cossmann, pp. 114–115)	2062	
Oligocene Gasteropoda	177	
Gasteropoda Pulmonata	70	
		2309
Eocene and Oligocene Scaphopoda	32	
		32
Eocene Cephalopoda	19	
		19
Total		3555

These figures convey an idea of the extreme richness of the Mollucan fauna of the Paris Basin, and show it to be at least three times as rich in species as the Eocene and Oligocene beds of the English area. This richness in species is also borne out in the vast numbers of individuals of the more common forms 'whose name is legion' in some spots.

We cannot close this brief notice without referring to the vast labour entailed by the preparation of a list of upwards of 3000 species, giving the range of each. Of course the works of Cossmann, Deshayes, and many others, have been used to aid this compilation, but the critical knowledge and care possessed and exercised by the authors could alone insure this part of the work being carried out correctly. The authors acknowledge that they have had valuable assistance in correcting their proofs from Mr. F. A. Bather, M.A., F.G.S., and in their biography from Mr. C. Davies Sherborn, F.G.S. There is an Index of Species and a General Index is also provided.

We heartily congratulate the authors on this valuable piece of work, and the Geologists' Association upon their courage in incurring the very large expense of printing it, which we sincerely trust they may recover on the sale of this very useful Memoir.

III.—The Physical Geology and Geography of Ireland. By Professor Edward Hull, M.A., LL.D., F.R.S., Second Edition, Revised, pp. 328. (London: Edward Stanford, 1891. Price 7*s*.)

AFTER an interval of thirteen years the author has given us a revised edition of his useful book, and, as he remarks, it comes by a happy coincidence concurrently with the completion of the Geological Survey of the country with which it deals. In bulk the work is larger by 37 pages, and it contains three more illustrations. Considerable portions of the work remain as in the original edition, but here and there corrections and additions have been made; the more important supplementary matter relating to the Archæan rocks, the Devonian rocks, the Volcanic rocks of Antrim, and to "the invasion of Ulster by a great ice-sheet from the Grampian Mountains of Scotland."

The work was reviewed at considerable length in the Geological Magazine for March and April, 1878 (pp. 121 and 167), and it is therefore needful only to draw attention to a few points in our present notice.

In the former edition Prof. Hull commenced with the Cambrian rocks; he now decides to "commence with the Archæan rocks, which are the oldest, and follow the course of the geological record downwards" (some would prefer to say *upwards*). A couple of pages serve to tell all the author has to say about these oldest of rocks, which consist chiefly of "gneiss with masses of schist." The principal areas occupied by these rocks are shown on the neat little geological map which accompanies this work, and the author candidly states, though in language that savours of a "bull," that with regard to his former conclusion (in 1882) that the granitic and gneissic rocks of north-west Donegal were of Archæan age, "this view, for which there is much conflicting evidence, I have been obliged to abandon." We think the author is right in using the term Archæan as a general group-name for rocks considered to be Pre-Cambrian; but he makes no reference to the term "Dalradian" (derived from the old kingdom of Dalriada in the north of Ireland), that has lately been suggested by Sir A. Geikie for the crystalline schists of the north of Ireland and the centre and south-west of Scotland. Already Prof. Hull's remarks on the "Lower Silurian" rocks of Donegal may need revision.

In his account of the Old Red Sandstone the author employs the name Devono-Silurian for the Glengariff Grits and Dingle Beds, which he regards as equivalent to the Downton Sandstones of Hereford and the Foreland grits and slates of North Devon. These beds are surmounted unconformably by the Upper Old Red Sandstone, and thus there is a great gap that may be elsewhere represented by the Middle Devonian.

Indications are given of the zones in the Carboniferous Limestone, for the recognition of which the labours of De Koninck are acknowledged.

Some criticisms are called for by the Table of Formations given on page 3, for the "Liassic group" is separated from the "Oolitic or Jurassic group." Hence the author is led to remark that the whole of the Jurassic series is unrepresented in Ireland, whereas it is customary to include both Lias and Oolites in the Jurassic system. Again he has given in upward succession above the Oolitic or Jurassic group, and ranged in similar type as if equivalent in value, the Purbeck Beds, Wealden Beds, Neocomian Beds, and the Lower Cretaceous Beds; a very unfortunate grouping to say the least of it, although it is true that these formations are simply noted for the sake of comparison with those represented in Ireland.

The author criticizes the view (put forward by Sir A. Geikie) that the trachytes and pitchstones of Antrim are far younger than the surrounding basaltic sheets, and he refers to the occurrence of numerous pebbles of Tardree trachyte in the stratified ash-beds which overlie the lower basaltic sheets in certain localities.

The Pliocene age of the clays of Lough Neagh is still maintained by the author, although the occurrence of "bivalve shells resembling a species of *Unio*, or *Mytilus*," cannot be said to count for much.

A good description of the Glacial Drifts follows. These include Lower Boulder-clay, Middle Sand and Gravel and Upper Boulder-clay. "The Lower Boulder-clay is the most extensively distributed of all the Post-Pliocene deposits in Ireland." It is a stiff clay with striated blocks. The "Middle Sand and Gravel" is stated to contain marine shells in various places, and "may be regarded as a formation of marine origin, which has been strewn over the bed of a comparatively shallow sea." Yet we find it at elevations of 1300 feet. The author is disposed to think that floating ice may have had something to do with the accumulation of some of these gravels; but he is led to infer a great depression, which must have reached

1500 feet below the existing level. How to reconcile all the facts and explanations is left a good deal to the imagination of the reader.

The formation of the Lower Boulder-clay is held to be due to ice, "either in the form of a glacier, or of a sheet spread over the country, and moving in certain directions." The Upper Boulder-clay, which by-the-bye "may easily be mistaken for the Lower Boulder-clay," sometimes shows traces of stratification, and is "just such a deposit as might be supposed to have been formed under the sea, the waters of which were laden with ice-rafts and bergs bearing stones and boulders which would constantly fall to the bottom as the ice melted away; while these waters were themselves rendered turgid by streams from glaciers entering from various directions."

The *first* part of the work is thus taken up with an account of the many geological formations that occur in Ireland; the *second* part deals with physical geography, with the 'birthday' of mountains, the origin of the Central Plain, and of river valleys and lakes; and the *third* part is devoted to the Glaciation of the country, concluding with some account of the Prehistoric Mammalia.

The work is pleasantly written and well calculated to arouse an interest in Irish geology; and from its containing the matured views of one who for many years directed the Geological Survey of the country, it will be read with interest by geologists in general.

IV.—SOME RECENT MEMOIRS ON PALÆOZOIC OSTRACODA.

I.—ULRICH, E. O., describing some new or little-known North-American Palæozoic Ostracoda (Journ. Cincinnati Soc. Nat. Hist., 1890 and 1891) adds very considerably to our knowledge of the—1. "Lower Silurian;" 2. "Upper Silurian and Devonian;" and 3. "Carboniferous" species. In the first group he finds reason to separate some known forms from *Beyrichia* as types of the new genera *Ctenobolbina* (with 5 species) and *Tretradella* (1 species); and to institute the new genera *Drepanella* (6 species) and *Jonesella* (4 species), both near *Bollia*. The other genera of this group, from Ohio, Kentucky, Tennessee, Indiana, Illinois, and Minnesota, here described and figured, are *Entomis*, 1 sp.; *Pontocypris* (?), 1 sp.; *Bollia*, 5 spp.; *Placentula*, 2; *Beyrichia*, 1; *Eurychilina*, 6; *Primitia*, 11; *Aparchites*, 1; *Leperditia*, 5 (including a clear determination of *L. fabulites*, Conrad): and *Isochilina*, 6 (one from Ontario). The second group come from Indiana, Ohio, and New-York State, and consist of *Leperditia*, *Isochilina*, *Aparchites*, and *Entomis*, 1 sp. each; *Æchmina*, 2 spp,; *Halliella*, gen. nov., 1; *Ctenobolbina*, 5; *Bollia*, 2; *Beyrichia*, 3; *Moorea*, 1; *Kirkbya*, 3; *Octonaria*, 4; *Bythocypris*, 3; *Bairdia* and *Pachydomella*, gen. nov., 1 sp. each; and *Barychilina*, gen. nov. 2. The third (Carboniferous) group comprises—*Leperditia*, 1 sp.; *Primitia*. 4 spp.; *Ulrichia*, 2; *Beyrichia*, 2; *Bollia* and *Moorea*, 1 each; *Kirkbya*, 5; *Cypridina*, *Cytherella*, *Bairdia*, and *Pontocypris* (?), 1 sp. each. The species are illustrated in eighteen plates with numerous figures in each, rather rough in execution, but sufficiently true in essential features.

II.—Jones, T. R., in the Contributions to Canadian Micro-Palæontology, part iii. 1891, pages 57–99, plates x.–xiii. describes:—1. Fifteen species and varieties of Ostracoda from the Cambro-Silurian of the Provinces of Ontario and Quebec and of Lake Winnipeg, thirteen being new; 2. Nineteen from the Silurian of Anticosti and the Saskatchewan district, including ten new forms; 3. Nine from the Devonian of Lake Winnepegosis, the Athabasca River, Ontario (Thedford), and the Hay River near the Great Slave Lake, six being new. The close alliance of so many forms generically and specifically is noticed, and the varietal links defined; more especially the earlier representative forms or predecessors of species flourishing at a later period. Such predecessors, if not directly and genetically related, certainly occur in older deposits.

Thus the well-known Trenton species *Leperditia fabulites* and *Louckiana* are scarcely distinguishable from some forms of the later Silurian *L. Hisingeri*; and *L. labrosa* is very close to *L. marginata* of the same date. Even *L. balthica* has a corresponding form, of little difference, in the Chazy, here designated var. *primæva*.

Other North-American Ostracods were described and figured in the Quart. Journ. Geol. Soc. 1890, pages 1–31, plates 1–4, and pages 533–556, plates 20–21. It may be noted that—(1) "*Primitia Morgani*," p. 5, pl. 4, fig. 6, is now *Ulrichia*; (2) "*Beyrichia Buchiana*?" at page 16, pl. 3, fig. 25, is probably an imperfect specimen of Ulrich's *B. persulcata*; (3) "*Beyrichia Clarkei*" at page 17, woodcut fig. 2, is almost, if not quite, a *Bollia*; (4) The new genus proposed by Mr. Ulrich for *B. ciliata* (*note*, p. 19) and its allies is *Ctenobolbina*; (5) "fig. 17" at p. 27, 3rd line from the bottom, should be "fig. 12"; (6) "*Primitia Walcotti*," p. 543, woodcut fig. 1, agrees with Mr. Ulrich's genus *Barychilina*; (7) The Canadian specimens enumerated at pages 550–554 have been described in detail, together with others, in part iii. of the "Contributions to Micro-Palæontology," 1891.

III.—Krause, A.—Wissenschaft. Beil. Programm Luisenstadt. Oberrealschule, Berlin, 1891; and Zeitsch. Deutsch. geol. Gesell. 1891, pages 488–521, plates 29–33. The Ostracoda found in the Silurian rocks of the gravel-drift of North Germany, as determined by the author and others, are here enumerated; and forty-six species are critically noted and figured. In a comprehensive Table of these North-German fossils (pp. 514–521) 84 species (20 of them new), besides several varieties, belonging to 18 genera, are enumerated, and their distribution shown according to—1. Their association with certain typical species of *Strepula* and *Beyrichia*: 2. Their occurrence in three kinds of Lower-Silurian rocks (27 species): 2. In three Upper-Silurian rocks (57 species): 4. Occurrence in the Prussian districts: 5, The probable origin of some species from Sweden and the Baltic Provinces.

T. R. J.

REPORTS AND PROCEEDINGS.

Address to the Geological Section of the British Association, by Professor T. Rupert Jones, F.R.S., F.G.S., President of the Section, Cardiff, August 19th, 1891.

(*Concluded from the November Number*, p. 524.)

Looking at these Coal-measures alone, and considering that slow depression accompanied their formation, the mind is strained in estimating the time required for the gradual subsidence to 10,000 feet, with shallow water always in place, and jungle growing steadily after jungle, inundation following inundation at intervals,—and is somewhat confused in reasoning on the possible causes and the exact processes by which not only the sinking of this region of the earth's crust was brought about, but how, in turn, the 10,000 feet of new accumulations and deposits were raised into the great undulations, which Professor Ramsay has described and depicted in his Memoir before mentioned, and how and when they were slowly worn down day by day into the present beautifully varied surface of South Wales and adjacent country.

I may here remark that the analogous coal-field of Nova Scotia, investigated by Sir W. E. Logan, Sir J. W. Dawson, and others has a thickness of 14,570 feet, including seventy-six seams of coal and ninety distinct Stigmarian underclays.

Mr. W. Galloway communicated, in 1885, to the Cardiff Naturalists' Society[1] some valuable observations on both the vertical and the horizontal occurrence of different coals in South Wales; and showed by a map (pl. iii.) where the 'seam-coal' mainly exists in the large *eastern* third; the 'intermediate coal' in the narrow *middle* third; and 'anthracite' in the *western* third of the Glamorgan-Monmouthshire area. He refers to the gradual transition from bituminous to anthracitic coal along a hypothetical *plane* passing through the coal-field, with its major axis lying E.N.E.—W.S.W., and its minor axis dipping at a very low angle towards S.S.E. He accepts Professor Geikie's tabular scheme of the strata at p. 24. Mr. W. Galloway has favoured me with the following remarks on the *vertical* place of the several kinds of coal in the series :—"The *long-flaming* bituminous seams are about 700 yards higher in the ground than the semi-bituminous seams; the semi-bituminous, or good *steam-coal* seams are 200 or 300 yards above the *dry steam-coal* seams; the last are perhaps 300 yards above the *bastard anthracites*; and these *inferior anthracites* may be 400 yards or more above the perfect *anthracites*. You have thus somewhere about, say, 1500 or 1600 yards from the *long-flaming* coals to the *anthracites*. It may be a good deal more in some parts of the coal-field; but, as the deepest shaft is only about 800 yards, we cannot get a direct measurement."

Of these three sorts of coal—the *long-flaming dry* coals above have some seams suitable for gas-making; the middle are *caking coal*, good for making coke; the others produce *dry steam-coal* and *anthracites*.

6. *Output of Coal in South Wales.*—The following is the official account of the quantity of coal raised in South Wales last year as compared with that got ten years ago :—

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[1] Trans. vol. xvii. 1886, pp. 20–34.

Table showing the Output of Coal in the South Wales District in the Years 1880 *and* 1890.

County.	1880.	1890.	Increase or Decrease in the ten years.
	Tons.	Tons.	Tons.
Breconshire	100,616	259,260	+158,644
Caemarthenshire	625,933	762,032	+136,099
Glamorganshire	15,320,096	21,426,415	+6,106,319
Monmouthshire	5,039,549	6,895,410	+1,855,861
Pembrokeshire	79,386	71,908	−7,478
Totals: South Wales.	21,165,580	29,415,025	+8,249,445

Total Output for the United Kingdom.

	1880.	1890.	Total Increase in the ten years.
	Tons.	Tons.	Tons.
England, Wales, Scotland and Ireland ...	146,969,409	181,614,288	34,644,879

Dr. E. Hull refers to the increased production in the South-Welsh Coal-field, together with remarks on other fields and the future supply and working of coal, in the "Transactions of the Edinburgh Geological Society," vol. vi. part 2, 1890, where also Mr. H. M. Cadell follows with valuable notes on the probable future of the coal-trade.

7. *Varieties of Coal.*—The coal of the British Coal-fields exhibits every variety of composition between *anthracite*, which is nearly pure carbon, and the so-called *bituminous coals*, such as ordinary coal and cannel coal (hydrocarbons), rich in hydrogen. Anthracitic beds are rarely seen except in districts where the strata have been much disturbed, or peculiarly affected by other circumstances. Heat, whether direct or induced by pressure, vertical or lateral, has probably been the important agent in depriving coal of its hydrogen with some of its carbon, and thus changing it into anthracite. Neither in this latter nor in the compact cannel coal are the laminar structure and symmetrical jointing so distinct as in the ordinary coals. The last lose their volatile hydrocarbons also by exposure to the air, at outcrops and in open faults; hence they are not nearly so good for burning as those got at a greater depth. As it is well to have definite notions as to the appearance and structure of the different kinds of coal, some notes on the several sorts will now be offered.[1]

Anthracite is glossy or semi-lustrous, sometimes iridescent; it ignites with difficulty, and burns without smoke, and with little flame, on account of no volatile hydrocarbons being formed during combustion. This purely carbonaceous material differs from ordinary coal by its brilliant, semi-metallic lustre, its greater density, hardness, and brittleness, and by its massive and conchoidal fracture with sharp edges. Some of it can be cut or turned on the lathe into fancy articles.

Called *anthracite* (from ἄνθραξ, coal) by Karsten and the older mineralogists, it is also known as mineral carbon, blind-coal, stone-coal, culm, glance-coal, and non-bituminous coal. It is mentioned by mineralogists and geologists as having been found at many places in the Alps, Pyrenees, France, Germany, the United States, and the British Isles, under various geological conditions; but in regular and extensive beds it occurs chiefly in Pennsylvania, and largely also in South Wales. It is reported to have been found in China and elsewhere.

In the Franco-Belgian coal-field the coals become more and more anthracitic as they pass down to greater depths; both kinds, therefore were of the same age in formation; in South Wales also, as already stated, the anthracite and the other coals are all of one age. The squeezing, faulting, and inversions in the former field are accompanied by an alteration of the highly bituminous coals into *dry coals and anthracite.*

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[1] Much information as to the constitution of coal and its varieties is given in Roland and Richardson's *Chemical Technology*.

An interesting historical sketch of the use of anthracite, and some systematic remarks on its distribution in South Wales, were given by J. P. Bevan, F.G.S., in the "Geologist," vol. ii. 1859, pp. 75–80.

The anthracite of Pennsylvania is traceable from the inner folds of the mountain chain, where the strata have become more and more crystalline, and contain graphite as well as this non-bituminous coal, westward into Ohio, where the same beds consist of ordinary coal. In the eastern part of the Alleghanies the coal has only 6 to 14 per cent. of volatile matter, further west 16 to 22 per cent., 30 to 35 per cent., and in Ohio 40 to 50 per cent. (Prestwich). This coal-field before compression was probably 900 miles long by more than 200 broad in some places (Lyell).

The depression of strata by accumulated sediment above them may raise their temperature by the rise of the isogeotherms (surfaces of equal subterranean temperature), and they may reach a relatively high temperature. "Mere descent to a great depth, however, will not necessarily result in any marked lithological change, as has been shown in the cases of the Nova-Scotian and South-Welsh coal-fields, where sandstones, shales, clays, and coal-seams can be proved to have been once depressed 14,000 to 17,000 feet below the sea-level, under an overlying mass of rock, and yet to have sustained no more serious alteration than the partial conversion of the coal into anthracite. They must have been kept for a long period exposed to a temperature of at least 212° Fahr. Such a temperature would have been sufficient to set some degree of internal change in progress had any appreciable quantity of water been present, whence the absence of alteration may perhaps be explicable on the supposition that those rocks were comparatively dry."[1]

Coal in contact with granite is changed into anthracite or graphite; when in contact with volcanic and trappean rocks, it may become coke (columnar or otherwise) or mere soot.

Steam coal is very compact, burns with little smoke, and contains so little bituminous matter that it is not liable to spontaneous combustion, whether pyrites be present or not. It is an intermediate kind of coal, having more hydrocarbon than any anthracite has.

Ordinary coal, *common coal*, *household coal*, *pit coal*, *black coal*, *coal proper*, *bituminous stone coal*; of this there are several sorts:—

1. *Caking coal*, *coking coal*, *bituminous coal* (not really bituminous, but containing the constituents of bitumen—7 to 9 per cent. of hydrogen, with carbon and oxygen, or 4 to 6 per cent. of hydrogen and 6 to 8 per cent. of oxygen). When heated, it undergoes a kind of fusion and 'cakes' together, one piece adhering to another by the soft bituminous matter into which it is mainly changed. Such coals are used for *coking*, coke being more or less impure carbon left after the hydrocarbons have been driven off.

2. *Cherry coal*, or *soft coal*, is thinly laminated, soft, velvety, *short-fractured*, *friable.*

3. *Splint coal* (breaking off in long 'boards,' and into fragments with angular ends called 'splints'—Mushet), *bone coal*, *hard coal*, *free-burning coal*, *dry coal* (passing into *shaly*, *slaty*, and *stony coal*). This is less bituminous than some of the foregoing; burns free and open (that is, without swelling and caking), with a long smoky flame; with less than 6 to 8 per cent. oxygen and 4 to 6 per cent hydrogen; it is also called *dry coal.* The *hard coal* comes out in long blocks; the *cherry coal* in short pieces.

Reedy coal has alternate layers of *splint coal* and *bright coal* (Mushet).

Cannel coal, or *parrot coal*, is compact, and varies from lustrous to a dull earthy aspect; breaks irregularly, but with a conchoidal (shell-like) fracture; can be polished and cut into ornaments in a lathe. Yields mineral oil by distillation. Much used in gas-making; not fit for coking.

Torbanite, *Torbanehill mineral*, *Boghead cannel-coal*, or *Boghead coal*, is a kind of dark brown cannel-coal, good for making gas and oil (parrafin, etc.), and gives a light, spongy coke. It consists of minute light brown granules of hydrocarbon, with some earthy matter and portions of the tissues of coal-plants.

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[1] Geikie, "Textbook," etc., 2nd edit., 1885, p. 273.

As a scheme for the general classification of coals the following table may be useful:—

Highly Bituminous. ...	Gas coals	Torbanite, cannel-coal, parrot-coal	Vegetable matter much altered.
		Tasmanite, Better-bed coal, etc.	Spore-coals.
Common Bituminous ...	Household coals ..	Caking and coking coal, cherry coal, splint coal, and other coals	Laminæ of charcoal (mother-coal) & hydrocarbon.
Semi-bituminous. ...	Free-burning steam coals ...	1. Charcoal deposited abundantly at first. 2. Hydrocarbon partially lost by change.	
Anthracitic ...	Nearly smokeless steam coal ...	Hydrocarbon nearly all lost by change.	
Anthracite ...	Smokeless coal ...	All the hydrocarbon lost by heat under pressure.	
Coke	1. Natural ... ... 2. Artificial ...	Hydrocarbon lost by heat without pressure.	

8. *Constituents of the Coal-measures and of Coal.*—Sandstone, shale, coal and clay, in successive repetition, constitute (as we all know) the main materials of the 'Coal-measures' ('measures' being an old mining term for strata). Each of these substances well deserves the close investigation they have received from numerous observers. We need not take the sandstone in hand now; it will be enough to say that the quartz-grains have been derived from the quartz of the same granite rocks which gave the little mica-flakes to mix with much of the sandstone, and the kaolin to form the basis of the shales and clays in the same great Carboniferous formation.

Shales and Ironstone.—The *shales* are varied; some are almost purely argillaceous; others contain carbonaceous matter in different proportions, even becoming quite black and bituminous. The lighter-coloured shales often have plant-remains, especially ferns, scattered through them, and even whole stems and branches of *Lepidodendron* and *Sigillaria*, squeezed flat, and reaching long distances. The darker shales also have plant-remains, but less perfect, and very often shells and other fossils, including relics of fish and numbers of small bivalved crustaceans; with regard to the last, the fishes, when alive, fed on the Cypridæ and other organisms, and in turn these little Ostracoda ate the dead fishes when they could.

Here and there are more or less continuous layers of *ironstone*, or more frequently groups of nodules parallel with the planes of bedding, and containing either parts of plants, more rarely small limuloids or other crustaceans, or even spiders, scorpions, insects, or relics of fishes and amphibia. In some cases the shales are of marine origin, judging from the character of the shells imbedded in them; but usually the evidence from the fossils is of a negative character. The shells that were formerly thought to be mussel-shells, like freshwater Unios, are now known to belong to a different family; and, not being quite the same as any known sea-shell, they may have been estuarine.

The nodular and the flat masses of clay-ironstones in the shales have been due to the formation of carbonic acid in the water and mud by the decomposition of vegetable matter and the removal of some oxygen from the peroxide of iron present there, and by the carbonic acid thereupon forming carbonate of iron. This then segregated around some organic object in the mud, and, mingled with clay, gave rise to nodules or larger masses of argillaceous ironstone.[1] In consolidating the nodules frequently split internally, and the fissures of retreat, filled with calcite, blende, pyrites, or other mineral, constitute *septa*, or divisions, in the *septarium* or septarian nodule. The so-called 'beetle-stones' are septarian nodules broken across, showing central and diverging lines.

The iron-ores of South Wales are fully treated of in the 'Memoirs Geol. Survey,' Iron-Ores, part iii. 1861, by E. Rodgers, and their fossils by J. W. Salter. From official sources we learn that the details of Production of Ironstone, chiefly Argillaceous Carbonate, from mines under the Coal-mines Regulation Act, for the year 1889 were—

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[1] De la Beche, "Memoirs Geol. Survey," vol. i. pp. 185, 186.

County.		Quantity.	Total quantity.	Average price per ton.	Total value of ironstone at the mine.	Amount of metal obtainable
		Tons.	Tons.	*s.* *d.*	£	Tons.
Breconshire	Eastern part of	50	512	11 6	29	12,548
	Western part of	462		9 0	208	
Caermarthenshire		—	118	9 0	53	
Glamorganshire ...	Eastern part of	—	23,764	9 0	10,694	
	Western part of	23,764				
Monmouthshire		—	17,435	11 6	10,025	
		24,276	41,829	—	21,009	—

In Mr. J. P. Lesley's "Manual of Coal," etc. 8vo. Philadelphia, 1856, at pp. 22, etc., the variations in shales, and their passage even into coal, as the proportion of carbonaceous (vegetable) matter increases by local conditions, are carefully detailed.

Coal, Mother-coal, Coal-balls, etc.—The *coal* itself, to which the shales ('batts,' 'binds,' etc., as they are variously termed) usually serve as a roof, or in which they form 'partings,' or thin intermediate layers, comes next to be considered. Some remarks on the different kinds of coal have already been made. Common black coal is easily seen to be composed of thin alternate laminæ of dull and bright material, and usually the blocks or pieces have flat sides nearly at right angles with those delicate layers of deposition. These faces are due to shrinkage-joints; one is termed the 'face' (as it is presented on the long edge of the seam exposed in working), or the 'bord,' and the other or cross joint is the end; the former is also called the 'cleat,' and this term is sometimes applied to both sets of joint-divisions. The block of coal usually breaks also along the flat laminæ, exposing a somewhat dull, charcoaly surface, more or less interfered with by the next-lying bright lamina. The dull parts are real charcoal, or decomposed wood, and soil the fingers when touched; whilst the bright, or hydrocarbon, portion keeps clean when dry. On the fire the coal breaks more easily along the laminæ, because the bright portion softens and swells up with its bituminous change, and the 'mineral charcoal,' or 'mother-coal,' keeps the portions distinct for a time; so also the jointings open then, or give way easily to the poker.

The *mineral charcoal* may readily be seen to be flat fragments of woody tissue in a carbonised state; it is more or less impregnated with bituminous or mineral matter from the associated beds, and retains the mineral matter of the original wood. It is due to "the chemical changes experienced by woody matter in decay in the presence of air," when "wood parts with its hydrogen and oxygen and a portion of its carbon, in the forms of water and carbonic acid. . . . Under water, or imbedded in aqueous deposits, the principal loss consists of carbon and oxygen; and the resulting coaly product contains proportionally more hydrogen than the original wood. This is the condition of the compact bituminous coal."[1]

The 'mother-coal' necessarily indicates a periodical change (maybe that of the rainy season) in the formation of a coal-seam, for it lay exposed, as decaying wood, whilst that which was accumulated just before must have been sufficiently covered up by water (a few inches may have been enough) to undergo the advanced chemical changes causing a proportional increase of hydrogen. The dead sticks and stems projecting out of and above the water-covered peaty mass below would naturally supply the decaying tonchwood and charcoal now lying as described above.

Doubtless a progressive change in the elaboration of hydrocarbon soon took place to some extent, even as it does in peat; but probably it was not completed in the compact coal until many layers of both vegetable and earthy matters had been accumulated (the former in place, and the latter from inundation), and caused some amount of pressure and consequent heat.

As, under favourable circumstances, the bright coal can be seen to have been made up of spores, leaves, branches, and stems of special trees, and other plants, the place of growth must have been a swampy forest or jungle, of enormous extent, probably in a warm (perhaps sub-tropical[1]) climate, to account for the hundreds of square miles of continuous coal-seams.

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[1] Dawson, *Quart. Journ. Geol. Soc.*, vol. xv. 1859, pp. 627, etc.

Much has been learnt from the broken and rotting ruins of a forest, standing on an area of the coal-growth, having been here and there sealed up and preserved in that original state, before hydrocarbonisation had proceeded far; whilst the rest of the fallen timber and accumulated relics passed into the state of bright coal, and became almost undistinguishable as to its structure except under the microscope after special manipulation. The 'coal-balls' of Oldham, in Lancashire, and the 'bullions' at South Owram, in Yorkshire, are calcareo-carbonaceous nodules, having been formed by the infiltration of water carrying carbonate of lime from the shells in an overlying shale down into the bed of woody fragments and other bits of dead plants. The carbonate of lime there segregated from the mass to certain centres, and preserved, in round nodules, the vegetable structures, before they were quite decomposed, more or less distinct as they had fallen on the forest floor. Hooker, Binney, Williamson, and others have elucidated much of the botany of the coal from this source.

In the Lower Carboniferous series at Pettycur Bay, Burntisland, in the Firth of Forth, are some well-preserved relics of the materials which would otherwise have been used to form a coal-seam (referred to by Williamson and Binney). In this case volcanic material has been ejected into or through a peaty mass, and, having removed by force some of the soft wet material, has been mixed up with it and settled down as a hard stratum, with well-preserved fragments of wood and other tissues, into which carbonate of lime was subsequently infiltered (Carruthers).

A third instance was discovered by Mr. Wünsch, in 1865, in the Lower Carboniferous series on the north-eastern shore of the Isle of Arran, where numerous plant-remains are well preserved in and under volcanic ashes. The strata are alternate sandy shales, thin coal-seams, and peperino-like tuff. Numerous truncated trees remain upright, rooted in the shale. *Sigillaria*, *Lepidodendron*, *Lepidophloios*, and *Halonia*, besides *Sphenopteris* and other ferns, are present.[2]

Cannel, etc.—Under the name of 'cannel' are known some important varieties of coal, useful for distillation and gas-making; and certainly they differed in their method of deposition both from ordinary coal and in some particulars among themselves. They all appear to have been formed of vegetable matter that, having been soaked and macerated to a black pulp, like the most rotten and semi-fluid peat, in lakes, lagoons, or other limited water-areas, became homogeneous masses of hydrocarbon, with much still discernible vegetable tissue, and occasionally with bones, teeth, and scales of fishes, and remains of *Amphibia*. Earthy matter was sometimes mixed with the cannel; and occasionally so much accumulated that the black mud graduated into carbonaceous shale. Light substances would also have been blown into the water by wind. According to the relative abundance of yellow-reddish hydrocarbons and macrospores, or of amorphous black substance (carbon) and microspores, is the difference between black and brown cannel (Carpenter).

Elsewhere the condition and place of the cannel are such as to suggest that, like a burst peat-bog of the present day (Buckland), the fluid carbonaceous pulp escaped from its birthplace, and found local hollows at lower levels that could receive and keep it. It is also suggested that such black, decomposed, fluid refuse of a swampy jungle, bordering a lagoon, might drain into the water, and settle as carbonaceous mud, or as coal itself, among the water-plants there (Grand'Eury). If poured in suddenly, it probably overwhelmed and poisoned many fishes. "The cannel coals, being wholly subaqueous, have not formed and do not possess mineral charcoal" (Dawson)

Torbanite consists almost entirely of minute sub-globular accretions of hydrocarbon (amber-coloured by transmitted light), derived either from chemical change of plant-remains, or more probably, directly from lycopodiaceous spores.

Spore-coal.—Very much of the substance of some coal-beds consists of lycopodiaceous spores that have been traced to the great lycopods, *Lepidodendron* and *Sigillaria*, allied to the club-mosses and *Selaginellæ*, and were probably shed periodically in enormous quantities (Prestwich and Morris, Hooker, Binney,

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[1] A great predominance of ferns and lycopods indicates moisture, equability of temperature, and freedom from frost, rather than intense heat (Lyell).

[2] Geol. Mag. 1865, and Trans. Geol. Soc. Glasgow, 1882.

Williamson, Carruthers, Balfour, Huxley, E. T. Newton, Orton, Dawson, Rheinsch, Wethered, Bennie, Kidston, and others). Mr. E. Wethered has suggested that the chief material in common coal was derived from the spores of a water-plant nearly allied to *Isoëtes*, and that woody material has supplied but little of the hydrocarbon. He objects to the theory of "submerged forests" because of the difficulty that Professor Dana has described, resulting in the calculation that for a four-foot seam of coal there would be required a thickness of 32 feet of accumulated forest vegetation and 48 feet for four feet of anthracite.[1] The macrospores of *Isoëtes lacustris* have been found in the mud dredged in Loch Coulter, Stirlingshire, by Mr. Thomas Scott.[2]

"Dawson is disposed to think that the tuberin of cork, of epidermis in general, and of spore-cases in particular, is a substance so rich in carbon that it is very near to coal, and so indestructible and impermeable to water that it has contributed more largely than anything else to the mineral."[3] Prestwich refers to these, and especially to gums and resins, as main constituents of the coal; and argues that the climate was warm and moist, with a larger percentage of carbonic acid than exists at the present day, and a more rapid plant-growth.[4]

Messrs. Bennie and Kidston[5] have not only carefully given the botanical history of *Lepidodendron* and *Sigillaria*, and of their fructification, but have described the spores met with in their examination of the Scotch Carboniferous strata, and have given their conclusions as to the nature and condition of the beds from which the spores were collected. The splint and parrot coals yielded most; the cherry or soft coals are too far bituminised to show them clearly, though present. Some fireclays yield them in the upper two or three inches. Some thin shales (plant-beds and fakes) yield spores, and some have plant-remains as well. "Carbonised wood was common in all the poor or shale-like coals. . . . Some of the thin coals were almost entirely composed of such carbonised vegetable matter." Fragments of scorpions and eurypterids occur plentifully in some of the 'old soils' (fireclays). The former, being land-animals, and probably adapted to a hot (or, at least, warm) climate, are among the most interesting of the coal-fossils.

Drift-coal.—Formerly, more so than now, it was thought by some that the coal had been formed by the accumulation of drifted timber and floating masses of vegetation in rivers and estuaries. There are several difficulties in the way of this hypothesis. There would have been more ash in the coal, because the water would shift and deposit sand and clay, together with rafts and grass islands; and the ash of pure coals agrees in relative quantity and composition with the earthy matter naturally contained in plants (Green and others). How far a calculation could be made as to a given quantity of ash in coal, and the amount of mineral matter belonging to plants, as a basis for proving the original quantity of woody matter concerned in a given quantity of coal, would be difficult to determine, for some of the original mineral constituents have been probably removed by percolating water.

Professor Lesley[6] has calculated that the Mississippi could not supply by driftage from the forests of its valley in 100,000 years wood enough for one of the Schuylkill anthracite beds; mineral sediments would also interfere with the results. Under favourable conditions, he adds, tropical forests (Central Africa) and coast-swamps (Florida, Guiana, India) would supply good and sufficient material. So also the swamps of the 'Sunk country' of Arkansas and Louisiana, as well as the 'Great Dismal Swamp' in Virginia, for one set of conditions (Lyell); and the mangrove jungles in the West Indies and elsewhere for another.

Fireclay, underclay, undercliff, underbed, seat-earth, seat stone, bottom-stone, spavin, clunch, fake, pouncin. This is usually a dense clay,[7] but sometimes sandy, and even altogether a hard sandstone ('ganister'). It varies in colour from black to white; and is from six inches to ten feet or more in thickness. A characteristic feature is its being penetrated in all directions by the stigmarian roots and rootlets of the trees (*Sigillaria*, *Lepidodendron*) that grew on it when it was the soil of the coal forest, having been slowly deposited by the quiet, shallow, muddy waters that succeeded the deposition of shale or sandstone by waters with stronger currents, these last terminating one of the periodical disturbances to which the many stages of gradual subsidence gave rise. Every coal-bed (or coal-seam, according to the application of those words to either a simple or compound layer of coal) lies on a more or less distinguishable 'underclay'; but this is often omitted to be recorded in coal-mining sections and documents.[1] Sometimes an underclay forms a roof of a coal; but it is the seat-earth of a coal lying on it.

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[1] Journ. Roy. Microsc. Soc. ser. 2, vol. v. 1885, pp. 406–420.

[2] Report of the Fishery Board, 1890.

[3] Balfour, "Palæontological Botany," 1872, p. 67.

[4] Geology, vol. ii. 1888, pp. 117–120.

[5] Proceed. Royal Phys. Soc., Edinburgh, vol. ix. 1886, pp. 82–117.

[6] 'Manual of Coal,' etc., 1856.

[7] In examining microscopically the ultimate particles of some shales and underclays, Mr. W. M. Hutchings has discovered that these are composed of a 'micaceous deposit,' in which there is some fragmental mica, but that the mass appears to con-

Denudation.—Among the many examples of denudation in the Coal-measures, coal-beds have been washed away from their underclays; but these latter are so greatly toughened by their contained network of roots that they have more effectually resisted denudation. Both coals and underclays, however, were not unfrequently destroyed, or, at least, deeply and widely channelled by contemporaneous floods and rivers; for not only are the 'horses,' 'lows,' and 'washes' such watercourses, but the occurrence of pebbles of coal and small detrital particles scattered through some of the sandstones are due to similar denudation.[2]

Sir J. W. Dawson, in 'Acadian Geology,' 1868, p. 139, states:—"The occasional inequalities of the floors of the coal-beds, the sand and gravel ridges which traverse them, the channels cut through the coal, the occurrence of patches of sand, and the insertion of wedges of such material splitting the beds, ... are constantly represented in modern swamps and marshes, more especially near their margins, or, where they are exposed to the effects of ocean storms or river inundations." The great thickness of coal and carbonaceous shale in the Albion Coal-measures at Picton, Nova Scotia, were formed in a depression separated by a shingle bar (conglomerate) from the more exposed flats outside.[3]

9. *Fossils of the Coal-measures of South Wales.*—An examination, or even an enumeration, of the fossils would be much more than we have time for now, whether we took in hand the *plants* or the *animals*.

I. Of the characters of the former[4] we have indicated some particulars, such as facts about the spores and roots of the gigantic trees of which the humble *Selaginella*, *Isoëtes*, *Sphagnum*, and *Equisetum* are the living representatives. Descriptions of their roots, trunks, leaves, woody and other structures have been given to the world by both Foreign and British palæobotanists in numerous goodly memoirs and volumes, illustrated with excellent plates; and the many ferns, tree-ferns, and cycadaceous plants (the last known by their fruits chiefly) have been well described and figured. Kidston's 'Catalogue of the Carboniferous Plants in the British Museum' gives full references to many of the above, and the others are well known. With increased knowledge, the supposed dome-like, long-armed, stigmarian plants, with subaqueous leaves or processes, either floating on or in the water, or growing on the mud, have become the depressed stools, dichotomous roots, and innumerable long, narrow, leaf-shaped rootlets of *Sigillaria* and *Lepidodendron* (Binney and others). C. Grand'Eury, however, still distinguishes some perfectly aquatic and peculiar plants, which floated in the water with their roots trailing on the bottom; and of *Stigmaria* he holds the opinion that it indicates a formation in deep water, contrary (as he says) to what is generally stated.[5] The supposed palms have disappeared in the explanation that the supposed fruits are only the marks of compressed gas bubbles fixed during their escape from the fœtid black, decomposing mud.[6]

sist mainly of minute, rutiliferous, mica-like flakes, regarded by him as of secondary origin, made from the original components of the stratum (Geol. Mag. 1890 and 1891). Mr. Hutchings kindly informs me that, of the numerous fireclays which he has examined, several are being used for brick-making (Letter, May 20, 1891).

[1] De la Beche, Mem. Geol. Survey, vol. i. pp. 173 and 177.

[2] Logan, De la Beche, Buddle, and others.

[3] Dawson, Q.J.G.S. vol. x. p. 46.

[4] A useful compendium of our knowledge of coal-plants in 1863, by Professor John Morris, was published in the Proceedings Geol. Assoc. of that date.

[5] Mém. présentés, etc., Acad. Sciences, etc., France, vol. xxiv. No. 1, 1877; and Annales des Mines, sér. 8, Mémoires, vol. i. 1882, p. 161.

[6] Carruthers, Geol. Mag. 1870, p. 215.

Great advances have been made by Prof. Dr. W. C. Williamson in the knowledge of the lycopodiaceous trees of the coal, which he shows to have partaken of the exogenous structure of modern trees.

Various more or less artistic representations of ideal coal-forests are to be met with, both in special books treating of the subject and in treatises on geology in general. Eloquent descriptions of such a forest by Ansted and Hugh Miller are quoted by Balfour.[1]

Of the flora of the Uplands, which were bordered by the peaty coal-swamps, very little is known; only that the fern fronds and some other plants in the roof shales, and the occasional either prostrate or snag-like trunks of conifers in the sandstones, were probably brought to lower levels by streams or river-floods (Dawson, Lyell, and others).

II. The fossil animals of the coal are necessarily of very great interest, but we can now refer to only a few.

1. Of the invertebrates a fair number occur in South Wales, but none of the insects, myriopods, spiders, scorpions, eurypterids, land shells, and other rare forms known elsewhere have yet been met with.

In the "Memoirs of the Geological Survey of Great Britain," etc., Iron-Ores, etc., Part III., the late Mr. J. W. Salter very carefully classified and tabulated the fossils found in the 'ironstone bands' of South Wales, describing and figuring the most characteristic species. He hoped to have taken up the fossils of the coal bands in like manner, but unfortunately the time never came. His observations at p. 220, on the importance of managers of collieries and others making very careful collections of fossils, with notes on their exact beds, should even now command attention. He notes as follows:—

Black Band; Anthracomya, Fish remains	Brackish.
Soap Vein; Worm-burrows, Anthracomya, Ferns	Brackish.
Black Pins; Anthracosia, Dadoxylon, Knorria, and Halonia ...	Brackish.
Ell Balls, above Elled Coal; Asterophyllites, Lepidodendron, and Ulodendron, Ferns	Brackish.
Under Big-vein Coal; Anthracosia	Brackish.
Over Three-quarter Coal; Anthracomya	Brackish.
Will Shone, or Pin Will Shone, over the Bydyllog Coal; Athyris	Marine.
Darran Pins; Anthracosia, Anthracomya, Myalina	Brackish.
Over Engine Coal; Spirifer and Productus, Fern	Marine.
Black band, over Old Coal; Anthracosia, Fish	Brackish.
Spotted Vein; Spirorbis; track of Limulus (?) 6 feet below the vein	Brackish.
Red Vein; Anthracosia, Modiola, Edmondia (?)	Marine?
Blue or Big Vein; Myalina, Anthracosia, Spirorbis	Marine?
Bottom Veins; Fish (8 genera)	Brackish.
Rosser Veins; (under the Farewell Rock and above the Millstone Grit); Brachiopoda (7 genera), Conchifera (8 genera), Gasteropoda, Heteropoda, and Cephalopoda (9 genera), Encrinite Stems, Fish remains	Marine.

Anthracosia[2] was originally regarded as a *Unio* by Sowerby, then referred to *Cardinia* by Agassiz, and to *Pachyodon* by Stutchbury; but it was ultimately defined by W. King as related to *Unio*, but, being distinct from that genus, it was named by him *Anthracosia*. Mr. Salter noticed that it has a wrinkled epidermis, and considered that it was related to the *Myadæ*, and of brackish, if not marine, habitat. This is the shell composing the so-called 'mussel bands' and 'Unio bands' of the Coal-measures.

Anthracomya, 'Iron-ores,' etc., page 229. Mr. Salter indicates that the shells which he describes under this name have oscillated in catalogues between *Avicula*, *Modiola*, and *Unio*, and that it has a wrinkled epidermis, like the foregoing.

Anthracoptera[3] is a triangular shell, with wrinkled epidermis, and belonging to the same group as the above.

All the forms of this characteristic group of Coal-measure shells are called *Naiadites* by Dawson,[4] and regarded by him as allied to D'Orbigny's *Byssoanodonta*.

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[1] "Palæont. Botany," pp. 70, 71.

[2] *Iron-Ores South Wales*, pp. 226, 227.

[3] Salter, *Q.J.G.S.* vol. xix. 1863, p. 80.

[4] *Acadian Geol.*, 1868, pp. 201–203.

Gümbel and Geinitz have described them as belonging to *Unio* and *Anodon;* and Ludwig refers *Anthracoptera* to *Dreissena*. At all events there is a great probability of their not being truly marine. They may have lived in the brackish water of lagoons and creeks in the black, muddy swamps, having some communication with the sea, and often or occasionally inundated with salt water (Dawson, Salter, etc.).

Spirorbis carbonarius is frequent in the Coal-measures of South Wales and elsewhere. This little annelid, though belonging to a marine genus, is often found attached to plant fragments in the coal-shales. These plants may have hung down into the water and been infested by the annelid; or it may have attached itself to floating plants which were ultimately drifted back to the littoral mud-swamp. This *Spirorbis* is an important constituent in the Ardwick limestone of Manchester and Shropshire, but is associated with Ostracoda (*Carbonia*), which are probably of brackish-water habitat.

The Brachiopoda are necessarily marine. The fish are not good witnesses, for they might have migrated to and fro, as some now inhabit both fresh and salt waters; and some might have been essentially estuarine.

Thus there are few decidedly marine beds in this series, and these, of course, correspond with the occasional domination of the sea during its inroads and during extreme depressions of the district.

In addition to the occurrences of fossils in Salter's list above quoted we may notice that in the Geol. Mag. 1870, pp. 214–220, is an account of some fossils discovered by the late Mr. W. Adams, of Cardiff, in 1869, in a 'Black Band' in the Rhymney Valley, about 800 feet higher in the Coal-measures of South Wales than any hitherto found. The band is calculated to have been rightly 81 feet above the Mynyddysllwyn coal, from which it is divided by a fault; it is in five layers and about 8 feet thick, with its associated shales. One of these in its midst and the lowest shale carry the fossils. With some plant remains there is *Anthracomya*, with *Estheria* (?) *Adamsii*, *E. tenella*, and *Leaia Leidyi*, all probably of brackish habitats; also *Carbonia Evelinæ* and *C. Agnes*, Ostracodes typical of a genus which is found in the black shales, presumably of either fresh or brackish-water origin. Mr. Adams also found a shale full of *Anthracomya* at Aberbeeg, Ebbw Vale, overlying the Troed-rhiw-Clawdd coal, and 226 yards below the Mynyddysllwyn coal (p. 215).

2. Of the Vertebrata the fishes enumerated in Mr. Salter's list are important. The following are the genera named:—Megalichthys, Rhizodus, Pleuracanthus, Byssacanthus (?), Palæoniscus, Amblypterus, Helodus, and Pœcilodus.

Although reptilian remains are rare in South Wales, yet they are not altogether wanting. In 1865[1] Professor (now Sir Richard) Owen described some remains of a small amphibian (between newt and lizard), found by the late J. E. Lee in the lower part of the Middle (or upper part of the Lower) Coal-meaures at Llantrissant, Glamorganshire. The animal was rather larger than the allied *Dendrerpeton Acadianum*, and Professor Owen named it *Anthrakerpeton crassosteum*, "the thick-boned coal-reptile." This paper and its illustrations were reproduced in the "Trans. Cardiff Nat. Soc."

10. *Extent of the Coal-measures under the South of England.*—Sir H. De la Beche in 1846[2] noted that a great sheet of Palæozoic rocks, including the Coal-measures, extending from Belgium to Central England, had been rolled about, undulated, crumbled, and then partially worn away before the New Red Sandstone and other Mesozoic strata were laid down upon them: and that these, in their turn, had been denuded so as to expose here and there portions of the underlying Coal-measures, though near by a ridge of profitless Mountain-limestone or other older rock might come to the surface.

In 1856 Mr. Godwin-Austen, following up his reasoning about the areas of coal-growth (see above, page 521), explained that the movements of disturbance which they had undergone had tended to preserve the great Franco-Belgian coal-band, and had rendered it available; and he proceeded to state that the course of that band of Coal-measures may be traceable westward, and probably coincided with, and may some day be reached along the line of, the Valley of the Thames.

Professor Prestwich in 1871 extended this inquiry;[3] and, having carefully compared the coal-beds of Somerset and Belgium, described the characters and relations of the strata in detail, and showed that the coal might be met with at a workable distance from the surface along a narrow but interrupted curved area from Westphalia, through Belgium and France, to England; then along the north-eastern part of Kent (Isle of Thanet, etc.), and through Herts, Bucks, Oxfordshire, Gloucestershire, to the Bristol coal-field, and on to South Wales. The coincident axis of disturbance is south of the river Thames, in his opinion throwing off the coal-beds on its northern flank.

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[1] Geol. Mag. Vol. II. pp. 6, 8, Plates I. and II.

[2] *Mem. Geol. Surv.*, vol. i. pp. 213–214.

[3] *Report Royal Commission Coal-Supply*, 1871; *Anniv. Address Geol. Soc.*,

Mr. W. Galloway has given in the "Cardiff Nat. Soc. Report," vol. xvii. 1856, p. 23, a sketch of the views here alluded to. A full account of the history and literature of the question of the underground range of the older rocks in the South-east of England, especially as to the possible occurrence of the Coal-measures, is published in the "Memoirs of the Geological Survey: The Geology of London and of Part of the Thames Valley," vol. i. 1889, pp. 13-28, by Mr. Whitaker, F.R.S., who, having given close attention to this subject, has suggested the following localities as likely sites in the search for coal in the South-east of England: St. Margaret's, Chartham, Chatham, and Shoreham, all in Kent; Bushey (Herts), Loughton (Essex), and Coombs, near Stowmarket (Suffolk).[1]

An interesting fact relating to this matter is that in February, 1890, the engineer of a boring at the foot of Shakespear's Cliff, Dover, announced that at 1204 feet below the surface there a thin seam of coal was met with, and at several yards lower down coal eight feet thick was pierced, associated with clays, grits, and blackish shales (Newspapers). In Dr. Blanford's "Anniversary Address to the Geological Society" on February 21, 1890, he stated that Professor Boyd Dawkins, in a letter received the day before, had informed him that a coal-seam had really "been reached at a depth of 1180 feet, and that this seam is proved to be of Carboniferous age by the plant-fossils in the associated clays. . . . The discovery is solely the result of scientific induction, and arrived at by following the line of research first indicated, I believe, by the late Mr. Godwin-Austen, and subsequently by Professor Prestwich." The boring was undertaken with the advice of Professor W. Boyd Dawkins;[2] and we learn, from his latest Report,[3] that the Coal-measures were reached at 1113 feet below high-water mark, and were penetrated to 1500 feet; also that in the 387 feet of Coal-measures six seams were met with, giving an aggregate of 10 feet of coal. The distance of the Coal-measures below high-water mark is a near approximation to Professor Prestwich's computation of the probable depth at which coal might be found in that part of Kent, namely, 1000 to 1100 feet[4] The account of the coal-plants or other fossils from these beds has not yet been published.

11. *Conclusion.*—The formation and subsequent arrangement of coal and the Coal-measures have been so ordered that the blessings of civilization have been largely enjoyed wherever the fossil fuel at man's feet has been industriously worked by his hands, and carefully applied to the improvement of his social being. These labours of careful perseverance, and arts of skilful manipulation, have given special characters to those whose energies have been directed to coal-mining and various manufacturing enterprises; and all conditions of society have been influenced thereby.

So also the geologist, chemist, and botanist, seeking out the composition of the various coals, their local position and extent, their special natural history, the mode of passage from dead plants to first-rate fuel—in fact, aiming at a complete mastery over all the mazy events and complicated results of the coal-formation—not only find a useful exercise of their cultivated intelligence and accumulated knowledge, benefiting all by the practical results, but they widen the mental culture of others, and show how the study of nature is an indispensable element in good education, and necessarily productive of lasting benefit to society at large.

1872; *Popular Science Review*, July, 1872; and *Proceed. Instit. Civil Engineers*, vol. xxxvii. 1874, p. 110, etc., plates viii. and ix.

[1] Geol. Mag. November, 1890.

[2] See also "Contemporary Review," April, 1890; and his "Lecture to the Royal Institution," June 6, 1890.

[3] "Report of Proceed. General Meeting of the South Eastern Railway Company," July 23, 1891, p. 10; and "Financial News," July 24, 1891.

[4] "Proceed. Instit. Civil Engineers," vol. xxxvii. 1874, pp. 16 and 26 of the separate paper.

Light, heat, motion, fragrance, and colour are all now obtainable from coal. What more could the sun himself do for us? It is as if the sunshine that cherished the luxuriant jungles of the past had been preserved in the coaly mass of the buried trees. Indeed, the light and heat of former days, expended in thus converting carbonic acid and water into coal, are here stored up for man. By converting coal into carbonic acid and water he can again evolve that heat and light, and use them in a thousand ways beneficial to his race—nay, essential to his very existence as a civilised being (J. W. Salter and others).

Nevertheless, a great deal has yet to be learnt about the natural history of the Coal-measures, the order and extent of the special kinds of their animals and plants, the time occupied in formation, and the geographical and hydrographical conditions. At all events, we know that all their strata have been arranged *in order*, have been buried under circumstances favourable to production of the various coaly fuels, and then turned up in *orderly disorder*, ready to the hand of man, and well adapted for his use in this passage-stage of his civilization and development, helping him, when intelligent, active, careful, and persevering, to higher ends. For we cannot doubt that all things here are arranged for his better being, his progress towards more and more useful arts, wider ranges of science, and fitter aptitudes of life, of which as yet we have but little conception. We are still the early settlers in a beautiful world, whose capabilities, imperfectly known as yet, wait until higher developments of man can understand them fully, and apply the results to the general good.

OBITUARY.

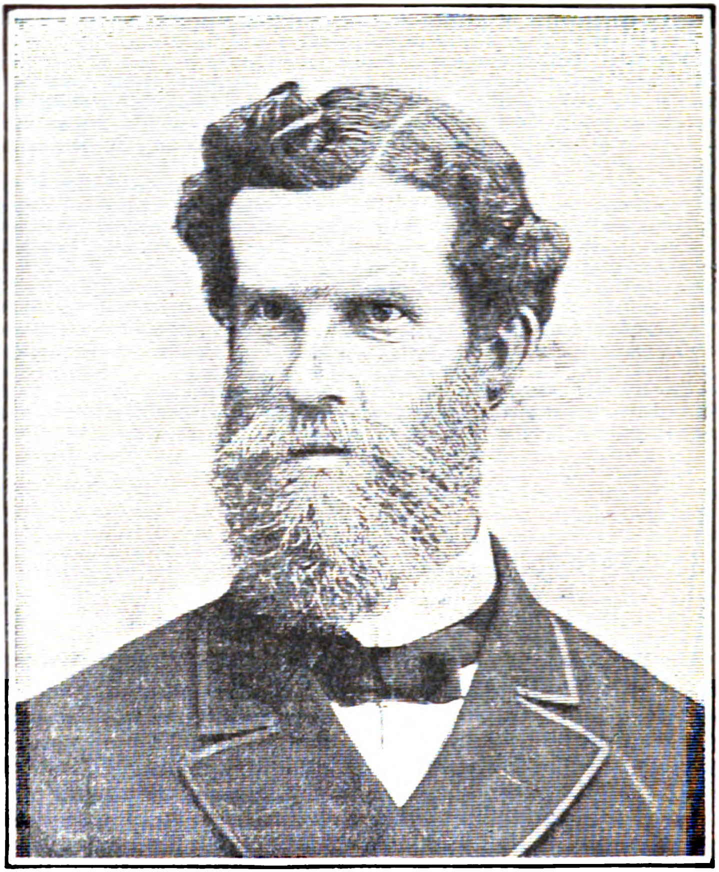
CHARLES SMITH WILKINSON, F.G.S., F.L.S., V.P.L.S.

NEW SOUTH WALES.

BORN 1843, DIED 23RD AUGUST, 1891.

Mr. WILKINSON was born in Northamptonshire. His father, Mr. David Wilkinson, was associated with George Stephenson in designing the first locomotive engines. His family settled in Melbourne in 1852, where he received his education. In 1859 he was appointed to the Geological Survey of Victoria under A. R. C. Selwyn, F.R.S., and in 1861 was employed in the Survey of the country from Bass's Straits northward to near Ballarat. Cape Otway mountains were surveyed by Mr. Wilkinson in 1863; and three years later, when engaged upon the Geological Survey of the Leigh's River District, some important investigations were made as to the mode of deposition of gold and the formation of gold-nuggets. Subsequently, Mr. Wilkinson's health gave way, and he spent three years in the Wagga district. In 1872 he passed the examination for licensed Surveyors in New South Wales, and was afterwards sent by the Surveyor-General to the then newly-discovered tin-mining district of New England, upon which he reported. He was appointed Geological Surveyor in the Department of Lands in 1874, and when, the following year, the Geological Survey was transferred to the Department of Mines, he was appointed Government Geologist for New South Wales, which office he filled until his death, with great ability and much advantage to the Colony.

Mr. Wilkinson was a member of the Board appointed to disburse the Parliamentary Vote for Government aid to mineral prospectors in his Colony. He has also served as President of the Royal Society of New South Wales and President of the Linnæan



Society of the Colony. His lengthened experience in practical geology and mining, and his scholarly attainments, united to a modest demeanour, gained for him a wide circle of friends both at home and in the Colonies. For seventeen years Mr. Wilkinson was a member of all Commissions for the Colony, in connexion with International and Inter-colonial Exhibitions, and he took a prominent part in preparing the collections showing the mineral resources of the Colony. He was also mainly responsible for the excellent collection of minerals in the Mining Museum at Sydney.

Mr. Wilkinson represented his Government as Geological Director of the New South Wales Royal Commission at the Mining Exhibition held at the Crystal Palace in the autumn of last year.

He was elected a Fellow of the Geological Society of London in 1876, and a Fellow of the Linnæan Society in 1881.

Note.—This Notice and the accompanying portrait of Mr. C. S. Wilkinson are reproduced, by the kind permission of the Editor, from the "Mining Journal" October 17, 1891.—Edit. Geol. Mag.

There may be many geologists in New South Wales ready to succeed Mr. Wilkinson in his post, but it will be difficult to find one possessing the same extensive geological and mineralogical knowledge, combined with so amiable a disposition and a readiness to impart information to those seeking it, which will cause his memory to be long held in esteem by all who had the pleasure to come in contact with him, whether officially or socially; and especially will his loss be deeply felt by a very wide circle of personal friends.

PHILIP HERBERT CARPENTER,

M.A., D.SC. (CAMB.). F.R.S., F.L.S.

BORN FEBRUARY 6TH, 1852. DIED OCTOBER 22ND, 1891.

PHILIP HERBERT CARPENTER, whose sad death we recorded in our last Number, was the fourth son of Dr. W. B. Carpenter, C.B., F.R.S. Born in Westminster, he was taught at University College School, and in 1871 went to Cambridge as a scholar of Trinity. In 1874 he graduated as B.A. in the first class of the Natural Science Tripos, and proceeded to the further degrees of M.A. in 1878 and D.Sc. in 1884. Between 1875 and 1877 he studied at Würzburg under Prof. Semper, and in the latter year was appointed assistant master at Eton College, being especially charged with the teaching of biology. This post he held until his death. In 1884, when his father received the Lyell Medal from the Geological Society of London, to Herbert Carpenter was awarded a moiety of the Fund. In 1885 he was elected a Fellow of the Royal Society, and he served on the Library Committee and Council of the Linnæan Society from 1887 onward.

By the death of Dr. Carpenter, at the early age of thirty-nine, we lose one of the chief authorities on Echinoderm morphology and the acknowledged leader in the study of the Crinoidea. For this position he was by his early training eminently fitted. As a boy his interest was excited by the researches which his father was prosecuting into the embryology and morphology of *Antedon*. When only sixteen he joined his father and Wyville Thomson on the deep-sea exploring expedition of H.M.S. *Lightning*, "manfully bearing no little hardship and helping to lighten the evil times to his seniors." It is interesting to remember that the chief incentive to that exploration was the discovery by Sars of new Crinoids in the North Sea two years before. In 1869 he was on the second and third cruises of the *Porcupine*, making analyses of sea-water, but no doubt keeping an eye on the many rare animals, especially Echinoderms, dredged by that vessel. The summer of 1870 was again spent on the *Porcupine*, this time in the Mediterranean. In 1875 he accompanied Sir G. Nares' Arctic Expedition as far as Disco Island, for the purpose of assisting in the dredging operations that were carried out there and in the North Atlantic by H.M.S. *Valorous*.

It was not, however, till September, 1875, that he turned his attention seriously to the Crinoidea, and then as it were by chance. His first studies at Würzburg were on "the minute anatomy of the genital glands in the Crayfish." It happened, however, that Semper and Ludwig had criticized certain statements of W. B. Carpenter with regard to the arms of *Antedon*, and P. H. Carpenter naturally wished to examine Semper's material. Thus his first paper (Journ. Anat. and Physiol.) reconciled the views of his father and of his father's critics. The interest once aroused led him on to the investigation of the Phillipine *Actinometræ*, placed in his hands by Semper, and after two years' work he presented to the Linnæan Society the important paper on that genus which is published in their Transactions. Meanwhile the *Challenger* expedition had returned, and in January, 1878, the description of the free-swimming Crinoids collected on it was entrusted to Carpenter by Sir Wyville Thomson. Thus his scientific career was determined, and from that time to his death, a constant stream of papers from his pen, on Echinoderm and especially Crinoid morphology, found their way to the Royal, Linnæan, Geological, and Zoological Societies of London; to the Quarterly Journal of Microscopical Science, the Annals and Magazine of Natural History, Zoologischer Anzeiger, and many other publications.

The report on the *Challenger* collection of Stalked Crinoids was to have been written by Wyville Thomson, but on his death in March, 1882, the work naturally fell to Carpenter. This report, published in 1884, and that on the unstalked forms, which appeared four years later, embody the main work of Carpenter's life: their accuracy and exhaustiveness are known to all who have to deal with Crinoids. This led to much other systematic work, such as that on the *Comatulæ* of the Leyden Museum, of the Hamburg Museum, of the Barent's and Kara seas, and of the Mergui Archipelago; besides much left unfinished on the Blake collections from the Carribbean sea, the Crinoids from the Port Philip Survey, from Torres Straits and elsewhere.

What must strike any one who reads these reports is the constant allusion to fossil forms. The refusal to separate for a moment the animals preserved to us in the rocks from those living in modern seas, which distinguished Carpenter's work from that of most zoologists, constitutes his chief claim on the attention of the readers of this MAGAZINE. "I have," he said "the strongest conviction (and many mistakes would be avoided were it a universal one) that the only way to understand fossils properly is to gain a thorough knowledge of the morphology of their living representatives. These, on the other hand, seem to me incompletely known if no account is taken of the life-forms which have preceded them." And this conviction was acted up to: thus, even a new *Antedon* from the Mergui Archipelago was shown by him to throw light on the position of Jurassic species. No stronger argument than the extreme value of all Carpenter's palæontological papers can be needed to show the utter fatuity of ever expecting really good work to be done upon fossils by those who are prohibited from acquiring a practical knowledge of their living relations. For those, however, less fortunate than himself his help was always ready, and none will feel his loss sooner or more bitterly than they who have so often availed themselves of it in solving the many problems presented by the Crinoids of the past. Besides many papers contributed to the Geological Society, Carpenter was joint author with Mr. R. Etheridge, jun., of the Catalogue of the Blastoidea in the British Museum; and the last number of the Journal of the Linnæan Society, published on the day of his funeral, contains a contribution to the Morphology of the Cystidea of the very highest importance (see *antea*, p. 135).

Carpenter's enthusiasm made him a keen controversialist, but his love of truth kept him open to every argument. He may have sacrificed brevity to exhaustiveness, but his conscientiousness has given to all his work the highest reputation for accuracy. These are the virtues of the man of science, but to them he added a kindness of heart and a bright joyousness of nature that leave us doubtful whether we have lost more in the teacher or in the friend.

Lists of Dr. P. H. Carpenter's papers, some written in conjunction with Mr. R. Etheridge, jun., are given in his two *Challenger* Reports, and in the Catalogue of the Blastoidea in the British Museum. To these the following list is supplementary.

1882. On the Relations of *Hybocrinus*, *Baerocrinus*, and *Hybocystites*, Quart. Journ. Geol. Soc. vol. xxxviii. (No. 151), pp. 298–312, pl. xi.
1886. Note on the Structure of *Crotalocrinus*, Ann. Mag. Nat. Hist. ser. 5, vol. xviii. pp. 397–406.
1887. Notes on Echinoderm Morphology, No. 11; on the Development of the Apical Plates in *Amphiura squamata*, Quart. Journ. Micr. Sci. vol. xxviii. pp. 303–317.
1889. Report on the Comatulæ of the Mergui Archipelago, etc., Journ. Linn. Soc. London (Zool.), vol. xxi. pp. 304–316, pls. xxvi. and xxvii.
1890. Preliminary Report on the Crinoidea obtained in the Port Phillip Biological Survey, Proc. Roy. Soc. Victoria, new series, vol. ii. pp. 135–136.
1890. On certain points in the Anatomical Nomenclature of Echinoderms, Ann. Mag. Nat. Hist. ser. 6, vol. vi. pp. 1–23.
1891. Some publications on American Carboniferous Echinoderms, Ann. Mag. Nat. Hist. ser. 6, vol. viii. pp. 94–100.
1891. On certain points in the Morphology of the Cystidea, Journ. Linn. Soc. London (Zool.), vol. xxiv. pp. 1–52, pl. i. Abstract in Rep. Brit. Assoc. for 1890, p. 821; and in GEOL. MAG. Dec. III. Vol. VIII. p. 135, March, 1891.
1891. Notes on some Arctic Comatulæ, Journ. Linn. Soc. London (Zool.), vol. xxiv. pp. 53–63, pl. ii.
1891. Notes on some Crinoids from the Neighbourhood of Madeira, *op. et tom. cit.* pp. 64–69.

Dr. Carpenter also contributed an admirable popular account of the Echinoderms to Cassell's Natural History (1883), and was largely responsible for the section on the same group in Nicholson and Lydekker's Palæontology (1889). F. A. B.

HENRY NOTTIDGE MOSELEY, LL.D., F.R.S., who, after a protracted illness, died on the 10th of November last, at the age of 46, was well known as a "Challenger" Naturalist, and as Linacre Professor of Comparative Anatomy at Oxford. That part of his published work of most interest to the palæontologist related to the Hydrocorallinæ, Alcyonaria and Madreporaria. But throughout his work, especially in his capacity as teacher, he was always alive to the value of fossils, and lost no opportunity of impressing on his pupils the importance of their study. His enthusiasm, his energy, his genial humour and his far-travelled experience would often keep the attention of his youthful hearers for a full hour beyond the appointed lecture-time; and, though his voice has for some years been silent, his memory will not yet cease to be dear to all who had the privilege of knowing him.

Thomas Pallister Barkas, F.G.S., was stricken with paralysis about a month prior to his death, which we regret to record occurred on the 13th of July last. He was born in Newcastle on the 5th of March, 1819, and in his early days was a well-known lecturer in his native city on scientific and literary subjects. To geologists he is best known by his "Coal-measure Palæontology" (1873), illustrative of the fauna of the Northumberland Coal Field. In this book he figured numerous specimens preserved in his own collection, and others which he had given to the local museums. Mr. Barkas was a great populariser of his favourite science, and took a warm interest in the Newcastle-on-Tyne Natural History Museum.

CORRESPONDENCE.

CONCERNING NOMENCLATURE.

Sir,—In reading Mr. J. W. Gregory's Revision of the British Tertiary Echinoidea in the "Proceedings of the Geologists' Association," vol. i. parts 1 and 2, 1891, I was, of course, impressed with the industry and acumen of the author, but I was much grieved at finding that ten of the original specific names given by Professor Edward Forbes in 1852 are maltreated by arbitrary and unnecessary alteration, after the latest fashion of pseudo-classical nomenclaturists, who propose to bring specific names to one artificial form and standard. They forget that the original "*Woodii,*" for instance, is preferable to *Woodi*, being more euphonious,—and that a name may be as lawfully latinized after the plan of *Junius* as of *Iulus*; and that there are as many Roman names ending in *ius* as in *us*. Further it seems to be forgotten, or not known, that the genitive in a specific proper name indicates the author's intention of honouring the discoverer of the specimen, whereas the adjectival form, as *Branderianus*, has reference to one otherwise connected with the species. Thus, to change "*Hemiaster Branderianus*" to *H. Branderi* is to falsify, not only the fact in nomenclature, but the author's intention to indicate the method and degree in which he meant to honour the person named. The reduction of capitals in specific names, as in *branderi*, is unworthy of real literateurs, convenient to printers, if any of them wish to save a little arm-stretching in composing the type,—and depriving both beginners and experts of seeing at a glance some indication of the scientific history of the species. Linné's method of giving initial capital to any noun used as a specific name is far preferable to the new fashion, which is probably based on the unimportant circumstance that in ancient inscriptions only uncial and uniform letters were used. T. Rupert Jones.

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